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NUCLEAR POWER PLANT SITING STUDY

for

DEPARTMENT OF THE ARMY  
OFFICE, CHIEF OF ENGINEERS  
WASHINGTON, D.C.

VOLUME I

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Submitted by

United Engineers  
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Having the most favorable overall characteristics. This site was further evaluated and found to viable based on supporting data.

An economic analysis was performed comparing the PE-CNSG to an equivalent coal-fired plant. The report concludes that at the expected utilization level of 45% of full mobilization requirements the nuclear system has a slight economic advantage versus the coal system. This advantage is increased at higher levels of production. No technological or sociological barriers which would preclude the implementation of the nuclear system were identified.

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## SECTION 1.0 INTRODUCTION

### 1.1 BACKGROUND AND PURPOSE OF THE STUDY

The implication of a repetition of the 1973 oil embargo and its attendant increase in the costs of fossil fuels has prompted greater interest in alternate energy sources by the Department of Defense (DOD). Concern over the availability of long-term fuel supplies, especially during full mobilization, has led to active consideration of the use of nuclear power plants to supply energy to military installations. Under the auspices of the Assistant Secretary of Defense, an ad hoc study group was formed to evaluate the environmental and economic considerations of using nuclear power at selected military installations. The Study Group is currently seeking to obtain more definitive information on the technical, economic and environmental feasibility of nuclear reactor siting for DOD installation support.

The purpose of this study is to perform a siting evaluation and a technical and economic assessment of a small nuclear reactor to support the Radford Army Ammunition Plant (RAAP).

### 1.2 REACTOR CONCEPT AND GROUND RULES FOR THE STUDY

As specified by DOD, this study is based upon the nuclear power plant technology developed under the sponsorship of the Maritime Administration and the Energy Research and Development Administration (ERDA) relating to the Babcock and Wilcox (B&W) Process Energy Consolidated Nuclear Steam Generator (PE-CNSG)\*, (Ref. 1.0-1 and 1.0-2, Section 1). Specifically DOD indicated that information on the reference nuclear power plant relating to

\*In this report, PE-CNSG refers to "Process Energy Consolidated Nuclear Steam Generator". Although the terms CNSG and PE-CNSG may be used interchangeably at times, the latter will be used almost entirely throughout the report.

specifications, costs, construction schedules, etc. would be available from studies performed under ERDA including the most recently updated work performed for ERDA on this subject (see Reference 3.0-1, Section 3).

Since United Engineers & Constructors (UE&C) participated in the latter study under contract E(11-1)-2477 in conjunction with B&W, it was possible to utilize the material developed for that work in the present study; although the final report was not available by July, 1975 as originally expected. For the present study, the plant concepts developed in the ERDA study have been modified as required for adaptation to RAAP. Those drawings, equipment lists, and portions of the cost estimate which have not required modification have been included as were originally prepared for ERDA and are, therefore, results of that study. It should be remarked, however, that equipment lists relating to the B&W Nuclear Steam Supply System and related equipment were developed by B&W in that study; although some modifications were required to the B&W reboiler for adaptation to the Radford Installation.

### 1.3 THE SITE

The Radford Army Ammunition Plant (RAAP) was chosen as a prime candidate to effect a realistic evaluation of the use of small nuclear reactors. RAAP is a government-owned, contractor-operated facility producing munitions for a variety of weapon systems. Hercules Incorporated has been RAAP's Contractor operator for more than twenty-five years and has more than fifty years of experience in the research, development, and manufacture of explosives and propellants. Hercules has its headquarters in Wilmington, Delaware.

Constructed during the pre-Pearl Harbor Emergency of 1941, the Radford Ordnance Works, as it was then known, rapidly developed into one of the most diversified ammunition plants in the world. On standby status after the Second World War, the plant was reactivated at the onset of the Korean War and has remained in operation ever since. The Ordnance Works was redesignated the Radford Army Ammunition Plant (RAAP) in mid-1963.

#### 1.4 ORGANIZATION AND OVERALL ACKNOWLEDGEMENTS

This report addresses the tasks described in Volume I of UE&C's Nuclear Power Plant Siting Study (Technical Proposal). As understood in that proposal, and in accordance with the contract for this work, the firm of Dames & Moore was assigned the responsibility of addressing the tasks mostly relating to site identification and evaluation under subcontract to UE&C, the main contractor for this study. All other tasks dealing with the technical and economic evaluation of the plant were the responsibility of UE&C.

In this report, all of the work performed by Dames & Moore in fulfillment of the tasks discussed above is contained in Section 2, Site Identification and Evaluation. Section 3, Plant Design and Cost Estimate, Section 4, Economic and Optimal System Evaluation, and all of the Appendices, were all prepared by UE&C and address the tasks referenced above.

## 1.5 EXECUTIVE SUMMARY AND CONCLUSIONS

A summary of the principal section of this report and the major conclusions of each are included below.

### 1.5.1 Section 2, Site Identification and Evaluation

#### 1.5.1.1 Scope

The major objectives in performing the evaluations contained in Section 2.0, Site Identification and Evaluation, have been to determine the feasibility of siting the B&W PE-CNSG, at RAAP. Section 2.0 provides a detailed discussion and description of those site-related tasks performed by Dames & Moore. These tasks included:

- 1) the identification of applicable siting criteria and development of a suitable site identification methodology in order to select a prime site area at RAAP.
- 2) specification of data requirements necessary for the study.
- 3) selection and detailed evaluation of the prime site in terms of safety, engineering, and environmental impact considerations, and
- 4) recommendations for alternative courses of action and/or additional work.

By the request of the Department of Defense, the study was conducted with strict adherence to federal siting guidelines and regulations. These guidelines include those normally used in siting and establishing site suitability for large-capacity commercial nuclear reactors. Because the site-related studies are only preliminary in nature and based on the data made available by the Department of Defense, the siting criteria and regulations were applied conservatively. That is, throughout Section 2.0, a high margin

of safety has been used in order to ensure the acceptability of the site under applicable regulatory requirements.

#### 1.5.1.2 Conclusions

After identifying a prime site area at RAAP, the site was investigated in detail in order to disclose major deleterious site characteristics that could preclude licensing by the United States Nuclear Regulatory Commission. The disciplines of demography and land use, meteorology, hydrology, geology and seismology, and aquatic and terrestrial ecology were reviewed following the federal guidelines and no significant site parameters were identified that would prevent licensing. However, there are a few site characteristics that could cause some licensing difficulties and may require additional considerations. These include possibly unacceptably high levels of transient activity in the exclusion area, the possibility that future population in the Low Population Zone may be unacceptable to the NRC, and that potential explosive hazards along transportation routes adjacent to the site may require additional safety features.

Aside from the aforementioned problem areas (which can be made acceptable through remedial engineering or by other means) there appears to be no reason that RAAP, and specifically site three, (Fig. 2-3), could not be used as a site for the PE-CNSG.

#### 1.5.1.3 Recommendations

The evaluation contained in Section 2.0 suggests that some subjects should be examined in more detail using site-specific data. Recommendations for additional work to remedy uncertainties include:

- 1) further definition of an adequate exclusion area radius for the PE-CNSG;
- 2) the potential for missile generation and explosions from RAAP, from the Norfolk and Western Railroad, and from State Route 659 should be investigated in more detail;
- 3) site-specific meteorological data should be obtained by constructing a meteorological tower on site. This activity could also result in a shortening of the licensing schedule, should the project go forward;
- 4) the effects of dam failure both upstream and downstream of the plant site should be evaluated;
- 5) the potential for ground water contamination in geologic formations below the site should be examined in greater detail;
- 6) more extensive geological and seismic investigations in the site and near vicinity are indicated. These include the performance of borings, geologic mapping to identify local faulting, and further analysis of the Safe Shutdown and Operating Basis Earthquakes;
- 7) it is also recommended that discussions with the Nuclear Regulatory Commission be initiated in order to define the possibility of obtaining waivers from certain guidelines (specifically in the areas of demography) based on the unique design advantages of the PE-CNSG.

#### 1.5.2 Section 3, Plant Design and Cost Estimate

##### 1.5.2.1 Plant Design

The two plant concepts previously developed under the sponsorship of the Maritime Administration and the Energy Research and Development

Administration were modified in the present study for adaptation to RAAP. Two important factors were the requirement of a mix of steam and electricity, and the lack of condensate return at RAAP.

For the case of the mix of steam and electricity a combination Turbine Generator/Process Steam System was conceptually designed to provide the recommended mix. The lack of condensate return was found to result in insufficient process steam quantities at the required conditions using the original reboiler design and, therefore, required modifications to that design. Southwest Engineering Co. provided information which was used to include an evaporator and a superheater combination in lieu of the original reboiler design. The plant was thus configured to export 570,000 #/hr of steam and 23 MW of electricity.

Other modifications were required due to the physical location of the plant and the water quality limitations at RAAP. These specific site characteristics affected the choice of cooling system and required that a water treatment facility be provided. A system with a mechanical draft cooling tower was selected.

Finally, a steam distribution system and the interface of the electrical distribution system were conceptually designed to interface with the existing systems.

#### 1.5.2.2 Cost Estimate

An equipment list, and a cost estimate for the modified plant were provided. Both of these were based on the cost estimate previously performed for the ERDA study of Reference 3.0-1. As with the plant layout, the major

modifications were due to the particular requirements of RAAP. Those items which did not change from the ERDA study were included to present a consistent estimate and overall equipment list. The format for presenting these items was, as much as possible, similar to the WASH-1230 series compiled by UESQ for the United States Atomic Energy Commission (Ref. 1.0-3, Section 1).

The plant cost estimated in 1976 dollars was \$125,000,000. With a contingency of 10% and after escalation and interest during construction a total estimate of \$250,000,000 was obtained for 1985. This figure refers to the PE-CNSG plant alone, modified as required for RAAP. It does not include the additional coal fired back up boilers, as discussed further in the overall economic assessment (Section 4).

In general, the cost estimate was conservative. However, it should be noted that the estimate of the engineering effort could conceivably be higher than the \$11,000,000 dollars used in the estimate by possibly \$5,000,000 dollars. However, considering that much of the additional effort representing the \$5,000,000 dollars might be performed by the Corps of Engineers itself and that the overall conclusions of the economic assessment in Section 4 are not affected by the difference, the value of \$11,000,000 dollars was used in the estimate.

#### 1.5.3 Section 4, Economic and Optimal System Evaluation

An overall economic evaluation of the PE-CNSG for RAAP was performed based on a comparison between a total system consisting of the PE-CNSG with a coal fired back up and the existing facilities and a total system consisting of only coal fired units.

The results of the evaluation lead to the following conclusions:

1. Economic characteristics of the nuclear system over the coal system is strongly dependent upon the expected utilization of RAAP. At 45% of peak full mobilization, the nuclear system has a slight economic advantage over the coal system. (Total present worth 1985 owning and operating costs of 619 Vs. 636 million dollars). At 60% of peak full mobilization, the nuclear system has a very significant economic advantage over the coal system. For the full mobilization case, the nuclear system has a substantial economic advantage over the coal system. (Total present worth 1985 owning and operating costs of  $\$506 \times 10^6$  vs.  $\$671 \times 10^6$ ). Clearly, the nuclear system's economic advantage over the coal system is increased with level of mobilization.
2. Parameters which can have a substantial effect on comparative economics are coal prices, base cost estimates for the nuclear plant, O&M costs for boiler plant with  $\text{SO}_2$  removal system, availability factor for PE-CNSG and escalation rates for various operating costs over the evaluation period.
3. Parameters which can have a significant effect on comparative economics are nuclear fuel costs, purchased electricity costs, plant life (evaluation period), nuclear plant O&M costs and escalation rate for base capital costs.
4. The economic evaluation presented here represents the situation for RAAP only, and does not represent a generalized evaluation of the

PE-CNSG vs. a coal fired plant. Structural characteristics of RAAP such as the existence of extraction turbines and associated equipment, building, etc., mean that the coal fired system is not penalized for associated capital costs. Also, substantial requirements for low pressure (40 PSI) steam means that a significant amount of low cost electricity can be generated (with the use of extraction turbines) in case of an all coal fired system. Furthermore, the amount of total steam requirements and the relatively large capacity of the PE-CNSG adversely affect the system with nuclear plant in terms of reliability considerations as well as the level of utilization which can be achieved for the PE-CNSG.

5. The optimum mix for the nuclear plant is a function of utilization of RAAP (Figure 4.24). For the case when RAAP is expected to operate at an average of 45% of peak full mobilization, the optimum mix is a gross electrical output of 30 MWe and a steam export capacity of 570,000 #/hr. For the 60% of peak full mobilization case, a mix with 20 to 25 MWe of gross electrical output seems to have some advantage over the all steam case. The advantage, however, is rather small and the recommended mix is all steam, which also reduces the capital investment requirements. For the full mobilization case, the optimum mix is all steam.
6. For each of the three optimum cases described above, a single 500,000 #/hr generating capacity coal fired boiler is used as a backup for meeting steam requirements. This will provide reliability equivalent to that of a coal system with three new boilers,

each with a generating capacity of 250,000 #/hr. It is possible that the size of the backup for nuclear plant can be reduced depending upon the exact nature of tradeoff between reliability and capital costs.

7. A sudden reactor shutdown (scram) can result in loss of steam supply to RAAP with, possibly, insufficient warning time and should be given further consideration. One way to alleviate the problem is to have the backup boiler in hot shut-down. This, however, can be expensive and the costs should be carefully evaluated against the benefits achieved.
8. The order of priority for meeting steam requirements (including 40 PSI steam) is nuclear plant, boilers in conjunction with extraction turbines and boilers alone. For meeting electrical requirements, the order of priority is nuclear plant, electricity available from the operation of extraction turbines, Appalachian Power and condensing turbines. (The desirability of Appalachian Power over condensing turbines depends upon the particular situation).

REFERENCES

- 1.0-1 U.S. Department of Commerce, Maritime Administration, Competitive Merchant Shop Program, Preliminary Safety Analysis Report, MA-940-01, February, 1973.
- 1.0-2 T. D. Anderson, et al, "An Assessment of Industrial Energy Options Based on Coal and Nuclear Systems", ORNL-4995, July, 1975.
- 1.0-3 Central Station Power Plant Investment Cost Studies WASH-1230, Vols. I through IV.

## SECTION 2.0 SITE IDENTIFICATION AND EVALUATION

### 2.1 INTRODUCTION

2.1.1 General. This section presents the criteria, methodology of site identification, and the evaluation of a prime site as a possible location for the Consolidated Nuclear Steam Generator (PE-CNSG) at the Radford Army Ammunition Plant (RAAP) near Radford, Virginia. The term site, as used throughout this section, is intended to mean RAAP.

RAAP is composed of two major components: the basic unit is the Radford Manufacturing plant (4154 acres), 3.2 miles northeast of Radford City, and the New River Storage Unit (2941 acres) located approximately 12 miles southeast of the main manufacturing facility. Complete and basically independent water, steam, and electrical systems for the Radford unit are included (Ref. 2.0-1).

2.1.2 Siting Options and Constraints. In siting power plants for electric utilities, the areal limits of most investigations are usually the boundaries of the utility's service area. In the case of the Radford AAP, the study area is confined to the presently existing plant boundaries for the following reasons:

- (a) there is a much greater control of activities on the base than would be possible at any other outside location;
- (b) present levels of security at the ammunition plant are high along with well-controlled access;
- (c) the plant should be located as close as possible to the existing steam supply system so as to minimize operating costs and impacts of construction activities;

- (d) because the ammunition plant has already caused substantial ecological manipulation, it would be more advantageous to site in such areas than in areas which have undergone little or no ecological disturbance; and
- (e) since there may be a suitable amount of land presently available at RAAP, the acquisition of new land outside the plant could add an unnecessary cost penalty to site development.

At the initiation of the project it was realized that the issues of seismology and foundation engineering might affect the use of RAAP as a potential location for a small (313 MW<sub>t</sub>) nuclear reactor. A preliminary evaluation of the Safe Shutdown Earthquake (SSE) for a nuclear reactor in the seismotectonic setting of southwestern Virginia revealed that a recurrence of the May 31, 1897 Intensity\* VII-VIII Giles County event at the site would cause accelerations which could exceed 30%g, depending upon the type of foundation material on which the plant was to be constructed. Also, the presence of extensive sinkholes throughout the area overlain by soil to a depth of 70 ft. made it clearly evident that sites with suitable foundation conditions should be found to ensure licenseability and minimize design and construction costs.

Subsequently, a boring program was initiated to verify foundation conditions at three sites identified at RAAP. Two of these sites were selected by the Department of the Army. A third site was identified after a review

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\* Modified Mercalli Intensity Scale of 1931.

of available boring logs, geologic maps, and air photographs of the site area taken prior to the development of the manufacturing facilities (1937). The sites are generally located as follows (Figure 2-3).

Site 1 - Located approximately 1.6 miles northeast of building 400 towards the eastern margin of the magazine area. The site is in the horseshoe bend on the New River. RAAP coordinates: N49+00; E42+00 (approximate).

Site 2 - Located approximately 0.8 miles southwest of building 400 on fire trail. RAAP reference coordinates: S36+00; W52+00 (approximate).

Site 3 - Located approximately 1.4 miles nearly due east of building 400 adjacent to Stroubles Creek. Radford AAP reference coordinates: N2+00; E50+00 (approximate).

An additional and major constraint considered in the process of site identification is the proximity to natural and man-made potentially hazardous areas. The production, storage, and testing of propellants and explosives at the Radford facility generally constitutes a highly hazardous land use. The siting of power plants in potentially hazardous areas is usually discouraged but does have some precedence in the Consumer's Power, Midland, Michigan site which is contiguous with a chemical plant to which the reactor will supply process steam. Topography and distance from hazardous areas have been considered as passive safeguards in the identification of candidate sites and in the selection of a prime site.

## 2.2 SITE IDENTIFICATION

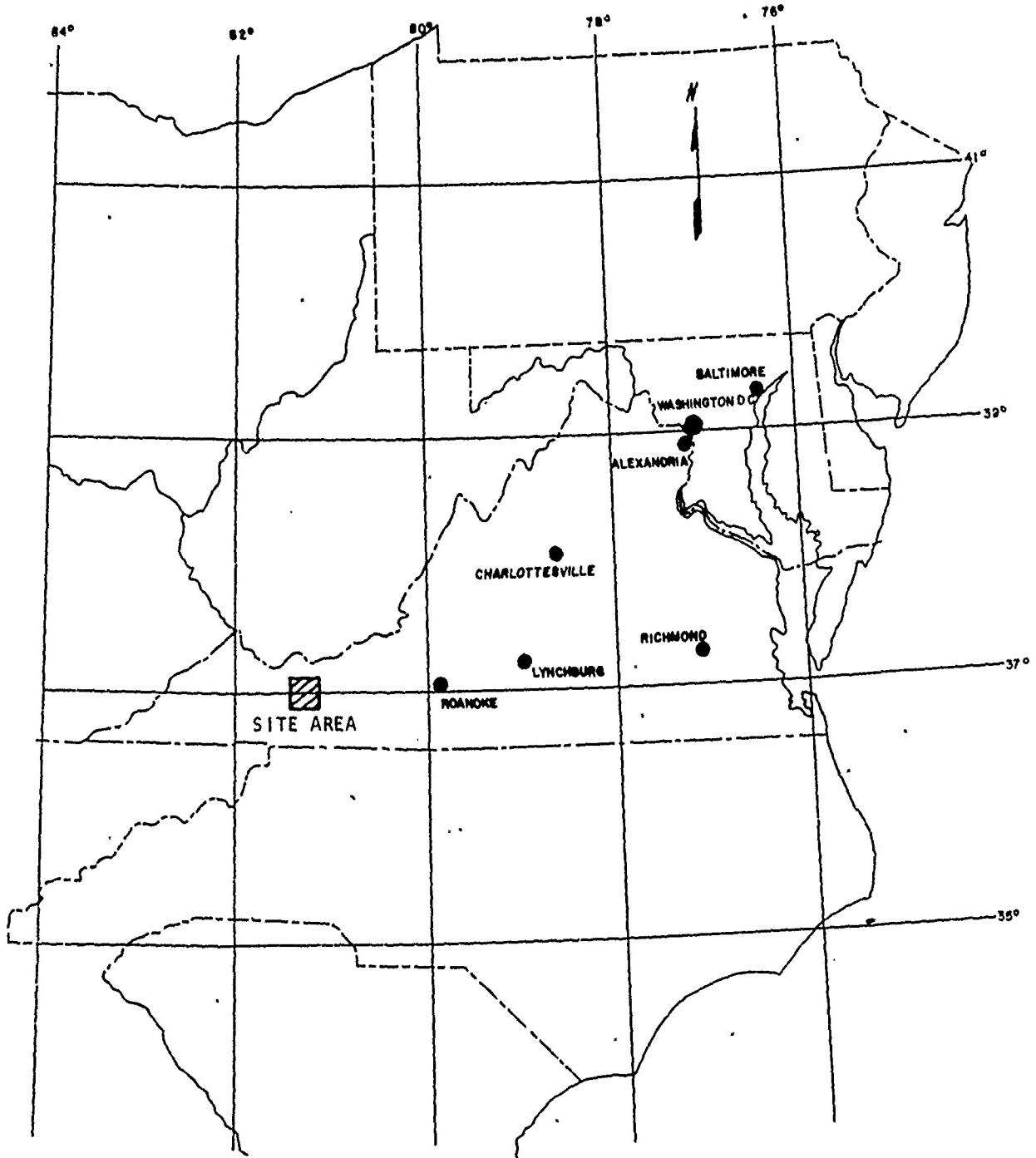
2.2.1 Data Requirements. Because of the great importance given to the safety and environmental aspects of siting nuclear power plants, Title 10 of

the Code of Federal Regulations, Part 100, "Reactor Site Criteria" (Ref. 2.0-2) requires that the population density, land use in the vicinity of the site, and the physical characteristics of the site, including seismology, geology, foundations, hydrology and meteorology, be studied in order to determine the acceptability of a site for a nuclear power reactor. In addition, the National Environmental Policy Act of 1969 (Ref. 2.0-3) requires that all agencies of the Federal Government prepare environmental statements for proposed facilities or land uses which may significantly affect the quality of the human environment.

The multidisciplinary nature of these requirements makes it necessary to evaluate a large amount of site-specific data which may or may not be available in the detail as required by federal and state regulations. Specific data requirements outlined in Regulatory Guide 4.7 General Site Suitability Criteria for Nuclear Power Stations (Ref. 2.0-4) and in WASH 1361 Safety-Related Site Parameters for Nuclear Power Plants (Ref. 2.0-5) are:

Hydrology: Probable Maximum flood (PMF); 7-Day, 10-Year recurrence low flow; water quality (ground and surface); ground water availability; bathymetric data; consumptive water use; water resources management.

Geology/Seismology: Surface faulting; local and regional geologic structure; geologic history of the site area; historic seismicity; historic ground motion; liquefaction, subsidence, and landslide potential; foundation conditions.



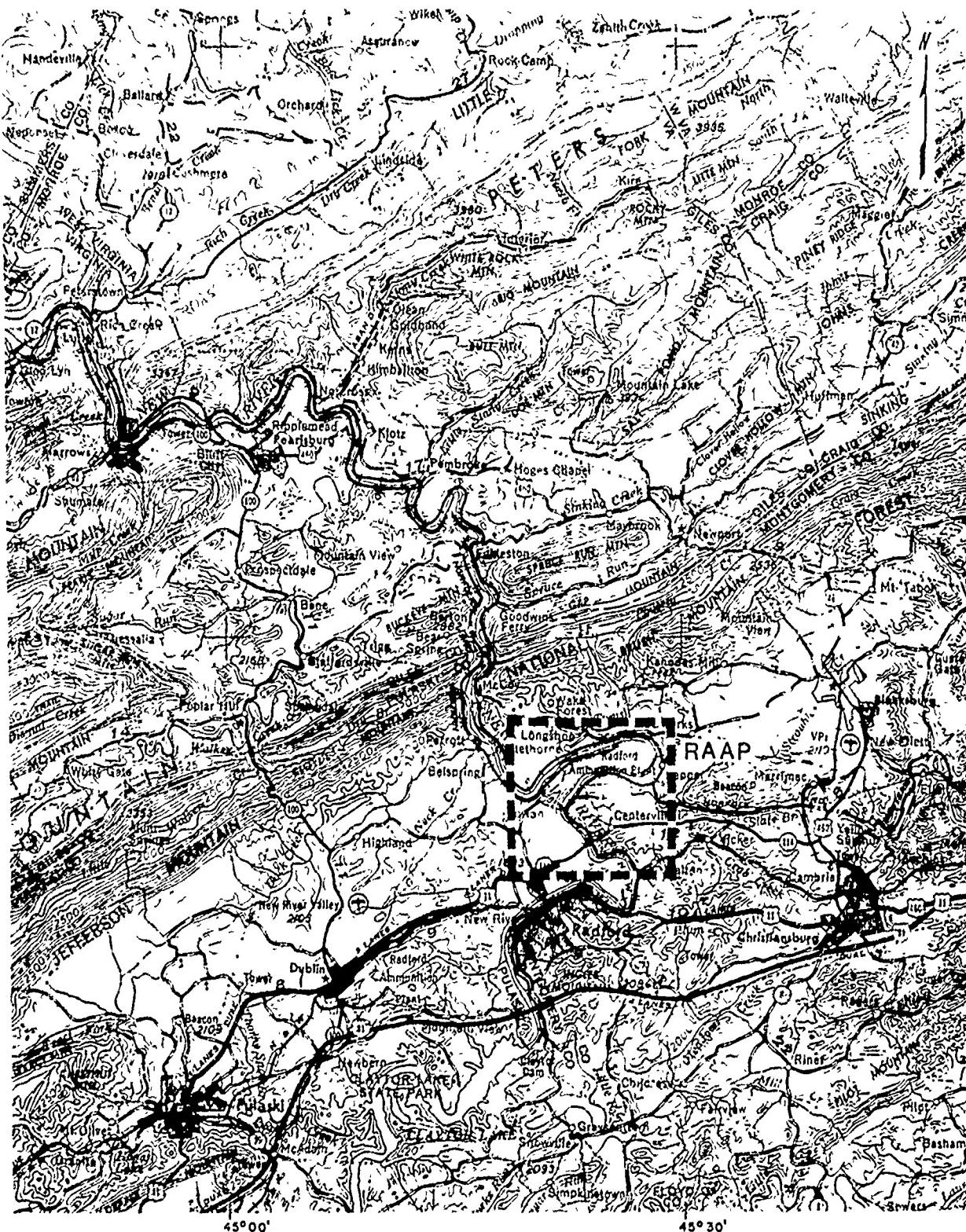
PROJECT LOCATION MAP

50 0 50 100  
MILES

REFERENCE:

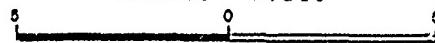
BASE MAP WAS PREPARED FROM PORTION OF THE DEPT. OF  
INTERIOR U.S.GEOLOGICAL SURVEY, MAP MF-620.

FIGURE 2-1



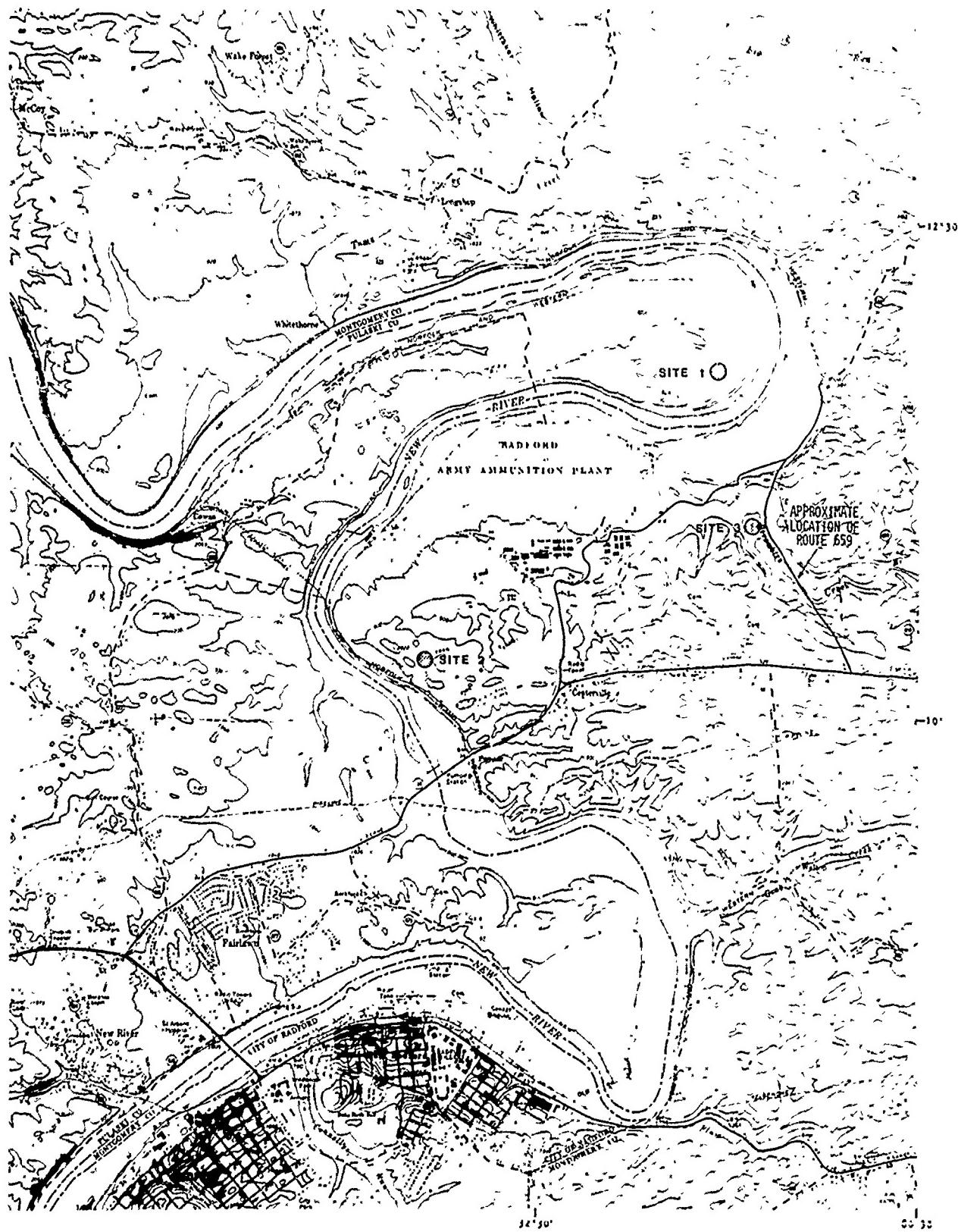
LOCATION OF THE RADFORD ARMY AMMUNITION PLANT

STATUTE MILES



REFERENCE:  
BASE MAP WAS PREPARED FROM PORTION OF THE  
USGS QUADRANGLE BLUEFIELD, W.VA., VA., KY., 1957

FIGURE 2-2



LOCATION OF THREE CANDIDATE SITES



FIGURE 2-3

Meteorology: Atmospheric extremes (precipitation, tornadoes, icing conditions, fogging); ambient atmospheric conditions; ambient air quality.

Demography: Population density; cumulative population; major population centers; transient population.

General Land Use: Location of nearby scenic, historical, or recreational areas; hazardous areas such as Industrial, Military, and Transportation facilities; type, amount, and frequency of transportation of hazardous materials near the site.

Terrestrial and Aquatic Ecology: Presence of rare and endangered species on or near the site; potential habitats for rare and endangered species; unique habitats and vegetation types; commercially or recreationally valuable resources; breeding, nursery, and spawning areas; migration routes; thermal and chemical tolerances of aquatic organisms.

Socioeconomics: Established and proposed public amenity areas; land use plans; labor force availability; community service facilities; and public acceptance of the proposed facility.

2.2.2 Data Availability and Collection. The roles of data availability and reliability play an important part in the site identification and evaluation processes. In the analysis of the three candidate sites, the factors of data availability and reliability have been taken into account by placing greater emphasis on those issues which can be adequately evaluated in terms of the available information.

Under the scope of work developed by the consultants and agreed to by the Office of the Chief of Engineers, the Department of Defense (DOD) has been charged with providing the required data to the consultants. Although it had been anticipated that only a minimal amount of effort would be required for data collection, it was necessary for the consultant to secure a large amount of data which was not provided by the Department of the Army. In instances where data was not readily available, either through the consultant or through DOD, these data were not collected. However, it is believed that the data which has been made available and integrated into the body of the report is sufficient for the purposes of this study and suitable to be used in the evaluation of RAAP as a site for a PE-CNSG.

### 2.2.3 Siting Criteria: Guidelines and Regulations

2.2.3.1 Siting Philosophy. The identification of sites for locating nuclear power plants requires land use planning that uses specific criteria developed by NRC, EPA, and where applicable, state and local guidelines and regulations. The primary objective of a siting study is to delineate candidate sites that are capable of sustaining a power plant of specified generating capacity without imposing an unnecessary stress or undue risks upon the natural and human environments while at the same time having favorable costs of development and operation.

Site identification studies performed by electric utilities are generally not as restrictive in terms of area. Utilities commonly study their service area with the only constraint being the size (in MWe capacity) of the needed facility. It is then the task of a multidisciplinary team of engineers and scientists to examine the plant/site interface, determining

the relative suitability of candidate sites, and present a ranking of suitable sites on the basis of engineering suitability, environmental sensitivity, and overall cost effectiveness of power generation.

The site identification study for the Department of Defense differs from this conventional utility procedure in a few major aspects:

- (a) The study area is restricted in its areal extent due to the economic constraints of the steam distribution system and the limited area of the Radford Army Ammunition Plant. This may partially prohibit the use of topography and distance as passive safeguards.
- (b) RAAP, being a munitions manufacturing and storage installation, presents a latent safety hazard to the proposed nuclear reactor. Engineering safeguards may be necessary to prevent missile impingement and also to minimize the affects of the interaction of the cooling tower plume with a postulated gaseous cloud containing toxic substances generated from nearby manufacturing facilities.
- (c) Because of the close proximity of each identified site to one another, only discrete differences between sites will be determinable. Site characteristics such as seismology, water availability, and population distribution will be very similar.

2.2.3.2 General Sources of Criteria. The identification and evaluation of candidate sites for a small (313 MW<sub>t</sub>) Pressurized Water Reactor is based on the same criteria employed in site suitability studies performed by public utilities for large nuclear power plants. Sources of these criteria include:

- (a) Nuclear Regulatory Commission's (NRC) Code of Federal Regulations (10 CFR), Parts 50, 51 and 100 (Ref. 2.0-2);
- (b) NRC Regulatory Guides (especially "Reg. Guide" 4.7, "General Site Suitability Criteria for Nuclear Power Stations (Ref. 2.0-4);
- (c) NRC Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Plants (Ref. 2.0-6);
- (d) WASH 1361, "Safety Related Site Parameters for Nuclear Power Plants (Ref. 2.0-5);
- (e) NRC Standard Review Plans (which offer the methodology of review utilized by the NRC in evaluating applications for Construction Permits and Operating Licenses);
- (f) National Environmental Policy Act of 1969 (Ref. 2.0-3);
- (g) Federal Water Pollution Control Act, Public Law 92-500 (Ref. 2.0-7).
- (h) Endangered Species Act of 1973 Public Law 93-205 (Ref. 2.0-8).

Conservatism in analysis and design is characteristic of all multidisciplinary studies for the evaluation of candidate nuclear power plant sites compared to the siting of less critical civil structures. In evaluating a potential site, a high margin of safety must be used to ensure acceptability of the site under applicable regulatory requirements. This will also lessen the likelihood of costly delays in the licensing processes. This higher margin of safety may be achieved by using conservative assumptions in site analysis and in the consideration of extreme conditions.

Where a simple analysis reveals marginally suitable site conditions which may significantly impact design and construction costs or where a site parameter value could preclude licensing approval, further analysis

should be performed to ascertain the practical range of conditions for which the facility may be designed and constructed economically while still being acceptable to the various regulatory agencies. These considerations include geology and demography, and man-made hazards.

2.2.3.3 Geology and Foundations. It must be demonstrated that a proposed nuclear power plant is adequately designed to safely accomodate severe natural phenomena. Among the most restrictive criteria used to postulate such phenomena and consequently affect plant design, are geology (faulting; subsidence; uplift) and seismology (earthquake induced ground motion; tsunamis; seismically induced flooding). Specific criteria derivable from the aforementioned sources explicitly state:

- (a) Sites that include capable faults are not suitable for a nuclear power station. A capable fault is defined as a fracture in the earth's crust along which differential movement has occurred at least once in 35,000 years or more than once in 500,000 years. Capability may also be determined by the association of macroseismicity with a known fault or by the association of an on-site fault with one of known capability.
- (b) Sites within five miles of a capable fault are generally not suitable for locating a nuclear power station.
- (c) Conservative design margins of safety-related structures will be required to allow for possible uncertainty in the geologic and seismic information.
- (d) Sites underlain with good quality bedrock generally have suitable foundation conditions. For sites underlain by soils, detailed investigations will be required to determine the static and

dynamic engineering properties of the soils. Subsurface materials with poor engineering characteristics should be excavated and replaced with engineering backfill.

2.2.3.4 Meteorology. The meteorology and climatology of a potential nuclear site are important engineering and public safety considerations. Extreme weather conditions such as hurricanes, tornadoes, and icing conditions impact upon site suitability but are not considered as being critical since their effects may be mitigated by engineering design. A more important meteorological consideration is the dispersion of radioactive emissions due to accidents and dispersion of normal operational releases of gaseous effluents. If the dispersion characteristics of a potential site are unacceptable to the NRC, the exclusion area around the plant may have to be enlarged to satisfy the dose criteria of 10 CFR Part 100. Presently, the NRC recommends a minimum exclusion distance of 0.4 mile even with unfavorable design basis atmospheric dispersion characteristics.

Another meteorological issue of concern is ambient air quality. For most sites air quality is unlikely to be a very important consideration unless the site is in an area where the existing air quality approaches or exceeds the limits specified in the Clean Air Amendments of 1970. Or where there is a possibility of mixing of cooling system effluents with gases and toxic elements from nearby industrial facilities.

2.2.3.5 Hydrology. Hydrologic considerations used in determining site suitability include flooding potential, water availability, and water quality. Flooding is a major concern in the site evaluation process since it may impair safe operation of the plant. Regulatory Guide 1.59 "Design Basis Floods for Nuclear Power Plants" (Ref. 2.2-8) details the required

analysis used in determining the Probable Maximum Flood (PMF) levels. For many power reactors which are now operating, the level of the design basis flood exceeds plant grade. Some of these plants have been protected by special plant design features or by external protective structures such as levees.

Regulatory Guide 1.59 states that the design basis flood should be considered as the worst case flood likely to affect the site during the operating life of the plant. This includes the PMF caused by the Probable Maximum Precipitation (PMP), wind generated waves during the PMF, multiple dam failures, and dam failures coupled with the simultaneous occurrence of the PMF. Regulatory Guide 1.59 outlines three methods of determining maximum high water as follows:

- 1) Calculation of the precipitation-induced PMF coupled with 40 mile-per-hour wind;
- 2) Single, or where applicable, multiple "domino-type" dam failures with the assumption of maximum pool elevation;
- 3) A combination of seismically induced dam failure and precipitation induced flood levels. This analysis should be performed for two specific cases:
  - a) Combination of the 25 year flood plus the Safe Shutdown Earthquake at the dam(s).
  - b) One-half the PMF plus a recurrence of the highest Intensity\* historic earthquake (similar to the plant's Operating Basis Earthquake).

\*Modified Mercalli Intensity Scale of 1931.

Water availability is a major concern in the siting of both nuclear and fossil fueled electric generating plants. The essential water requirements for a nuclear plant are that:

1. Sufficient water be available for normal plant operation,
2. In case of normal or emergency shutdown a 30-day supply of cooling water is available, to provide an ultimate heat sink for dilution and diffusion of waste heat, and
3. There is adequate water available for fire protection.

Section 316(a) of the Federal Water Pollution Control Act (FWPCA; PL92-500) requires that closed cycle cooling systems (cooling towers) should be used for power plants unless it can be demonstrated that a closed cycle system is more stringent than necessary to "assure the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife." To meet this requirement, it is necessary to perform a detailed analysis of stream flow characteristics and aquatic ecology without any guarantee that a once through system would be acceptable.

2.2.3.6 Biota and Ecological Systems. The primary criterion employed in the environmental assessment of site suitability is that the ecology of the proposed site (and adjacent areas) be sufficiently understood to predict "whether there would be unacceptable or unnecessary deleterious impacts on populations of important species, or on ecological systems with which they are associated, from the construction or operation of a nuclear power station at the site (Ref. 2.0-4). Once the potential impacts of construction and operation are known it is necessary to perform a cost benefit analysis to determine if the deleterious impacts can be effectively and economically mitigated by proper construction planning and remedial engineering design.

Disregarding all but biological criteria, site selection is not based on where to locate a power plant, but rather where not to site one. This rationale follows from the Principal of Ecological Succession; the orderly process of community development by means of internal manipulation with the result being a stabilized ecosystem. Thus, mature ecosystems such as hardwoods are considered more valuable than areas which have undergone substantial human manipulation (such as croplands, old fields) because of the time and energy investment by nature to produce them. Specific areas to be avoided are:

- (a) Federal and state protected lands. From biological and recreational perspectives, these areas are valuable because they often include pristine or unique habitats.
- (b) Wetlands. Saltwater, freshwater, and brackish marshes and wetlands, defined as any land with water regimes from seasonal submergence to year long flooding and waterlogging, are rapidly disappearing. Because of their high biological productivity and use as spawning and nursery grounds, these wildlife habitats are considered as undesirable potential power plant sites.
- (c) Habitats or potential habitats of rare and endangered species.
- (d) Constricted migratory flyways or pathways, spawning and breeding grounds, and harvest areas of commercially and recreationally valuable species.

Consumptive water use and diffusion of waste heat into the aquatic environment are major constraints in power plant siting. Present regulations limit the extraction of water from a river to 10 to 20 percent of the 7-day

10-year historical low flow rate. Remedial engineering measures may be required to prevent entrainment of, and thermal barriers to, aquatic species.

2.2.3.7 Demography, Land Use, and Economics. Population density is a major factor in defining unsuitable potential sites. The NRC has recommended that nuclear plants be located such that the population within 5, 10, 20, 40, and 50 miles of the plant not exceed a cumulative population of 30,000, 125,000, 500,000, 2,000,000 and 3,100,000 respectively. These numbers refer to the projected population, allowing for growth during the service life of the plant and include daily and seasonal variations. The effect of the recommendation is to discourage siting near cities or in areas of heavy population. Exceeding these values will require the detailed analysis of alternate sites in order to show that the prime site is the most favorable even with its poor population distribution characteristics.

Other demographic guidelines considered for this study include a minimum exclusion area of 0.4 miles and a low population zone of approximately 3.0 miles. The distance between the reactor and population centers of 25,000 or more persons should be at least one and one-third times the low population zone radius (Ref. 2.0-2).

"Exclusion area means that area surrounding the reactor in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency,

to protect the public health and safety. Residence within the exclusion area shall normally be prohibited" (Ref. 2.0-2).

"Low population zone means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident" (Ref. 2.0-2). Both the exclusion area radius and the low population zone radius are functions of plant design to minimize effects of radioactive releases during accidents.

The NRC requires that the reallocation of lands to be used for a potential site be evaluated and that such a reallocation be consistent with land use plans adopted by Federal, State, and local agencies. Sites adjacent to "distinctive" communities or tourist areas should be evaluated with respect to the operation of the proposed plant. These "distinctive" areas may include lands administered by governmental agencies for scenic or recreational uses. To determine the acceptability of potential sites near these special areas it is necessary to consult with the applicable government agencies.

The aesthetic impact of power plants and transmission facilities is another item which concerns the NRC and other regulatory agencies. These impacts should be determined for each candidate site and remedial engineering methods proposed to minimize or mitigate the predicted impacts. Typical remedial methods include relocating the plant to take advantage of existing topography, restoration of natural vegetation, creative landscaping, and the use of architectural colors compatible with the natural environment.

The social and economic issues relevant to power plant siting and the evaluation of potential sites are probably the most difficult of all issues to quantify. The siting, construction, and operation of an electric generating station may have significant impacts (both positive and negative) on a well-balanced community and may disrupt the local work force, transportation facilities, and community services in general. Commonly these impacts vary in their timing; construction activities may turn a stable community into a boom town for a short period of time, then when construction halts, the boom ends and the community may become economically depressed unless proper measures are instituted early in the planning stage.

The economic and social acceptability of a potential power plant site should be jointly investigated by the owning utility along with local governmental agencies and interest groups. An attempt should be made to project both the long and short term impacts and plans should be developed to minimize the adverse impacts.

2.2.3.8 Safety-Related Siting Considerations. The siting of nuclear power plants adjacent to or near industrial, military, and transportation facilities should be avoided since the probability of an accident is much greater in these areas than for areas which are primarily agricultural or non-industrial. It must be demonstrated for sites located in potentially hazardous areas, that, in the event of a major accident, the plant can be shutdown quickly and efficiently or, that the nearby industrial facilities can be altered so that their mode of operation will not significantly increase the probability of potential accidents.

Types of accidents and their associated concerns are explosions and their associated shock waves, flammable vapor clouds, toxic gases and chemicals, and aircraft or missile impingement. With respect to the latter, airports pose special hazards to nuclear power plants because of the frequency of aircraft movements in the near vicinity of the plant. Remedial engineering may be necessary if an analysis of air transportation at the site shows an accident probability greater than the limits set by the Nuclear Regulatory Commission. The necessary engineering safeguards usually consist of hardening (concrete and steel reinforcing) and fire protection for those structures critical to the safe operation and orderly shutdown of the plant.

The analysis for accidents resulting from the transportation of hazardous materials in the vicinity of the proposed site requires that data be collected concerning type of hazardous material, amount being transported, and frequency of movements. Should the analyses show accident probabilities greater than about  $10^{-7}$ , it would be necessary to perform a more detailed analysis to determine the consequences of such events and to provide engineering safeguards to mitigate the effects of a postulated accident.

2.2.3.9 Virginia Water Quality Guidelines. As required by Amendments to the Federal Water Pollution Control Act, enacted in October 1972, the State of Virginia submitted its standards for inter- and intrastate waters to the Administrator of the Environmental Protection Agency. Following some amendments to Virginia's standards, the regulations were approved by the Administrator (Ref. 2.0-10).

The Virginia State Water Control Board has had organized water quality standards for state-wide application and by river basin. These standards are summarized as follows:

- (a) State waters shall be maintained so as to permit beneficial uses and foster the propagation of all aquatic life.
- (b) State waters shall be free from waste substances (including heat) in concentrations which contravene standards or interfere with beneficial uses.
- (c) Zones for mixing wastes with receiving waters shall be determined on a case by case basis and shall not substitute for waste treatment. Suitable passageways shall be provided for fish and aquatic organisms. Such passageways should contain preferably 75 percent of the cross-sectional area and/or volume of flow of the receiving waters.
- (d) Stream standards will apply wherever flows are equal to, or greater than, the minimum mean 7-consecutive day drought flow with a 10-year return frequency.
- (e) In lakes and reservoirs the temperature of the epilimnion, in those areas where important organisms are most likely to be affected, shall not be raised more than  $3^{\circ}\text{F}$ , above that which existed before the addition of heat of artificial origin.
- (f) For discharges to sources of public or municipal water supplies, the standards presented in Table 2.2-1 will apply at the raw water intake point.
- (g) Waters whose existing quality is better than the established standards will be maintained at high quality unless it has been

TABLE 2.2-1: RULES WITH SPECIFIC APPLICATION BASED ON CLIMATE, GEOGRAPHIC AREA, OR USES

## Primary Classification of Waters Within the State

MAJOR CLASS	GEOGRAPHICAL AREA OR OTHER DESCRIPTION OF WATERS	DISSOLVED OXYGEN mg/l			pH	TEMPERATURE °F Rise above Natural*	**Maximum Hourly Maximum Change
		Minimum	Daily Average				
I	Open Ocean (Seaside of the Land Mass)	5.0	--	6.0-8.5		4.0 (Sept.-May) 1.5 (June-Aug.)	-- 2
II	Estuarine (Tidal Water - Coastal Zone to Fall Line)	4.0		5.0	6.0-8.5	4.0 (Sept.-May) 1.5 (June-Aug.)	-- 2
III	Free Flowing Streams (Coastal Zone and Piedmont Zone to the Crest of the Mountains)	4.0	5.0	6.0-8.5		5	90 2
IV	Mountainous Zone	4.0	5.0	6.0-8.5		5	87 2
V	Put and Take Trout Waters	5.0	6.0	6.0-8.5		5***	70 2
VI	Natural Trout Water	6.0	7.0	6.0-8.5		5***	68 2

\* Natural temperature is that temperature of a body of water due solely to natural conditions without the influence of any point-source discharges.

\*\* The maximum hourly temperature change of 2° F is to apply beyond the boundaries of mixing zones and does not apply to temperatures caused by natural conditions.

\*\*\* Any rise above natural temperature to be allowed by the Board shall be determined on a case-by-case basis, but in no instance shall exceed 5° F.

Reference: Water Quality Standards, Virginia State Water Control Board, November 1974.

TABLE 2.2-1 (Continued)

<u>Constituent</u>	<u>Concentration</u>
<u>Physical:</u>	
Color (color units)	75
<u>Inorganic Chemicals</u>	
Alkalinity	30-500
Arsenic	0.05
Barium	1.0
Boron	1.0
Cadmium	0.01
Chloride	250
Chromium, hexavalent	0.05
Copper	1.0
Fluoride	1.7
Iron (filterable)	0.3
Lead	0.05
Manganese (filterable)	0.05
Nitrates plus nitrites	10 (as N)
Selenium	0.01
Silver	0.05
Sulfate	250
Total dissolved solids (filterable residue)	500
Uranyl ion	5
<u>Organic Chemicals</u>	
Carbon Chloroform (CCE)	0.15
Cyanide	0.20
Methylene blue active substances	0.5
Pesticides:	
Aldrin	0.017
Chlordane	0.003
DDT	0.042
Dieldrin	0.017
Endrin	0.001
Heptachlor	0.018
Heptachlor epoxide	0.018
Lindane	0.056
Methoxychlor	0.035
Organic phosphates plus Carbamates	0.1
Toxaphene	0.005
Herbicides:	
2, 4-D plus 2,4,5-T plus 2,4,5-TP	0.1
Phenols	0.001
<u>Radioactivity:</u>	
Gross beta	1,000
Radium-226	3
Strontium-90	10

affirmatively demonstrated that a change is justifiable to provide necessary economic or social development.

- (h) Based on climate, geographical location, or type (tidal, free-flowing, etc.), all waters will be assigned a major class I-VI and a subclass A or B, to indicate the appropriate coliform standard. Waters used for primary contact recreation will be assigned subclass B. All other waters will be assigned subclass A and will be suitable for secondary contact recreation and for use as a public water supply.
- (i) All waters within Virginia will be satisfactory for fishing and secondary contact recreation.

The New River and most of its tributaries from the Montgomery-Giles County line upstream to the Virginia-North Carolina State line is classified by the Virginia State Water Control Board as being in the Mountainous Zone. The river is generally satisfactory for use as a public or municipal water supply, secondary contact recreation, propagation of fish and aquatic life, and other beneficial uses.

Standards for fecal coliforms (multiple-tube fermentation or MF count) are not to exceed a log mean of 1000/100 ml. and not to equal or exceed 2000/100 ml. in more than 10% of samples (Ref. 2.0-10).

#### 2.2.4 METHODOLOGY OF PRIME SITE IDENTIFICATION

2.2.4.1 Preliminary Overview of the Study Area. At the initiation of the project a preliminary overview of the study area was performed in order to identify the major issues of concern that would affect licensing, site development, and environmental and design costs. Once these issues were identified and the overall suitability of the study area established, it

was then possible to develop a work plan designed to emphasize the study of the most important issues. In this manner it was possible to avoid the expenditure of a large amount of time for the study of non-critical issues which would have little impact on the licensability and overall suitability of the candidate sites.

2.2.4.2 Data Analysis and Rating System. Data analysis for the site identification process consisted of a weighted rating scheme. Site characteristics were determined with respect to the design parameters of the proposed reactor, and the degree of compatibility measured at the plant/site interface was evaluated in terms of applicable nuclear power plant siting criteria. Although it was believed that such an analysis would be objective and highly reproducible, some degree of subjectivity would be necessary in order to avoid creating too rigid an analysis scheme. By structuring the analysis in a logical and systematic manner, and evaluating the site characteristics individually, it was possible to minimize judgemental errors by using a five-level subjective rating scale. This method prevented cumulative judgemental errors since each variable was rated by an experienced engineer or scientist knowledgeable in his particular discipline and in the aspects of selecting and evaluating potential nuclear power plant sites. The subjective rating scale used for this analysis is as follows:

Rating = 0      the site characteristic is restrictive and cannot be mitigated by reasonable engineering methods;

Rating = 1      the site characteristic is poor, there are many problems, some of which cannot be remedied by engineering alternatives;

- Rating = 2 the site characteristic is poor to average; conditions may be mitigated but only at moderate to high expense;
- Rating = 3 The site characteristic is average and remedial methods are simple but moderately costly;
- Rating = 4 the site characteristic is moderate to good with only remedial engineering required; and
- Rating = 5 the site characteristic is good and no remedial action necessary.

The restrictive rating of zero (0) is only used where there are legal restrictions placed on the site (coastal zones, wetlands, state parks, etc.) or where there are no acceptable engineering solutions (surface rupture of faults, extremely poor foundation conditions, etc.). In the case of engineering and safety criteria, there are very few site conditions which would restrict the use of a particular location for a nuclear power plant. However, in many cases the costs of remedial engineering and potential licensing difficulties may preclude the use of certain sites.

2.2.4.3 Weighted Issues. Because the selection of sites for nuclear power stations involves a number of complex issues that may vary in their relative importance, it was necessary to devise a systematic weighting scheme to consider each issue in a proper perspective. The use of such weighting schemes becomes more effective as the physical and environmental diversity of the study area decreases, thus making possible more discrete comparisons of sites. This was particularly true of the Radford AAP where the study area consisted of only 4154 acres ( $6.5 \text{ mi}^2$ ) and was relatively homogeneous in its physical and environmental characteristics.

The first step in the weighting process was to separate the engineering considerations from the environmental issues. In essence, this distinguishes the more objective and economic concerns from the subjective, imprecise non-economic issues. The individual disciplines in each of the main groups were then weighted by a technique in which each participant made a subjective judgment concerning the relative weight of each discipline or issue.

2.2.5 Review of Three Candidate Sites. This section presents a brief discussion of each of the issues studied, gives a weighted value to each issue, and presents site ratings for each of the three candidate sites. In some instances an issue is discussed but no ratings are given, or the sites are rated equally because the issue or physical characteristics through which the issue is interpreted affects all three sites in the same manner. It must be noted that the weighting scheme used for sites at RAAP were developed for this plant. Army manufacturing facilities in other areas of the United States that might be considered as possible locations for a nuclear steam generator should be addressed on a case-by-case basis.

Figure 2-3 shows the sites that were considered:

Site 1 Located approximately 1.6 miles northeast of building 400 towards the eastern margin of the magazine area. The site is inside the horseshoe bend on the New River. RAAP

reference coordinates: N49+00; E42+00 (approximate).

Site 2 Located approximately 0.8 miles southwest of building 400 on fire trail. RAAP reference coordinates: S36+00; W52+00 (approximate).

Site 3 Located approximately 1.4 miles nearly due east of building 400 adjacent to Stroubles Creek. Radford AAP reference coordinates: N2+00; E50+00 (approximate).

2.2.5.1 Seismology. A preliminary review of the study area revealed that historical seismicity could be a major limiting factor in the selection of RAAP as a site. Once the feasibility of siting at RAAP had been ascertained, seismicity was no longer considered a decisive issue for site identification since the attenuation of seismic waves from the operating basis earthquake epicenter would be similar for all three sites. The design value for the Safe Shutdown Earthquake\* (an Intensity VIII located at the site) would be primarily determined by the nature of subsurface conditions - whether the plant is underlain by rock or soils. Thus the issue of seismic design would be based on foundation conditions and is appropriately discussed in the section concerning Foundation Engineering.

2.2.5.2 Foundation Engineering. Foundation stability under the action of static and dynamic loads is of primary importance in the design and licensing of safety related structures for nuclear power plants. Four major considerations include bearing capacity, compressibility, potential for liquefaction, and response to, or modification of, seismic waves. Other considerations are the size and depth of excavation required and whether or not it may be necessary to replace excavated materials with engineered backfill.

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\* For definitions of the safe shutdown and operating basis earthquakes see 10CFR100, Appendix A.

(a) Site-1

Three borings were drilled at Site #1 each laid out on the apexes of a seventy-five foot equilateral triangle. Rock (limestone and dolomite) was encountered at 34 ft., 35 ft., and 44 ft. A generalized soil profile description is as follows:

<u>Depth</u>	<u>Description</u>
0 to 0.5 ft:	Brown topsoil.
0.5 to 5 ft:	Silt and clay, micaceous; trace of very fine to fine sand, yellow-brown, low plasticity, moist (ML-CL).*
5 to 12 ft:	Silt, micaceous; little very fine sand, trace of clay, yellow-brown, slight plasticity, moist (ML).
12 to 24 ft:	Sand, fine to medium with coarse material, little silt and pea-sized gravel, yellow to reddish-brown, not plastic, very moist (SM).
24 to 24.5 ft:	Gravel (GP).
24.5 to 34 ft:	Gravel and sand-sized limestone fragments, little silt and clay, grey to greenish grey, slightly plastic (GM-GC, saprolite).
34 to 36.5 ft:	Top of rock; dolomite, blue-grey, fragmental, hard, dense, slightly weathered. 100% recovery; very poor RQD (Rock Quality Designation).
36.5 to 39.0 ft:	Interbed of tan, very fine grained limestone with near vertical bedding.

\* Unified Soil Classification System.

39.0 to 65.8 ft: Breccia, limy and silty, grey to yellow-brown, partially fragmental with no pronounced bedding, soft to moderately hard, moderately weathered 0 to 100% recovery; RQD very poor to fair.

65.8 to 96.0 ft: Dolomite-- Limestone, green to blue-grey, fragmental, moderately hard, dense, slightly weathered. 0 to 100% recovery; RQD poor.

96.0 to 111.0 ft: Limestone breccia, blue-grey to dark grey, partially fragmental w/no pronounced bedding, soft to moderately hard, dense, moderately weathered. 27 to 46% recovery; RQD poor.

111.0 to 129.3 ft: Limestone-Dolomite, green-grey to light grey, fragmental and platy, dense closely spaced fractures, weathered. 62 to 90% recovery, RQD fair to poor.

129.3 to 150.0 ft: Limestone breccia, blue-grey to dark grey, no pronounced bedding, soft to moderately hard, closely spaced fractures, moderately to highly weathered. 53 to 93% recovery; RQD fair to good, bottom of hole.

Foundation conditions at site one (1), based on the borings performed by the Corps of Engineers, can be considered very poor with respect to siting a nuclear reactor. It is probable that an excavation to a depth of up to fifty feet would be required and that the excavation material would have to be replaced with engineered backfill. Also, based on poor recoveries and very poor RQD's, it is possible, and more likely probable, that the

carbonate rocks underlying the site are solutioned. Aerial photographs indicate the presence of sinkholes and cavities at site one (1). An extensive geotechnical investigation would be required to ascertain the extent of these conditions and it would probably be necessary to grout the underground openings if present. Furthermore, the fact that the reactor would have to be founded on deep soils could increase the acceleration values for the Safe Shutdown and Operating Basis Earthquake design values.

(b) Site-2

Three borings were performed at Site two (2) laid out in a similar manner to those at Site one (1). Rock (limestone) was encountered at 2 ft., 3 ft., and 6 ft. A generalized soil profile description is as follows:

<u>Depth</u>	<u>Description</u>
0 to 60 ft:	Silt, trace to little clay, yellow to red-brown with rock structure prominent (ML).
6.0 to 20.8 ft:	Limestone, light blue-grey, tan mottled, appears massive but thin to very thin bedded, beds dip 20° to 25°, shaly interbeds throughout, hard, dense, fractures along bedding, calcite stringers. Clay seam 8.8 to 9.2 ft. 75 to 100% recovery; RQD good.
20.8 to 37.4 ft:	Limestone becoming crystalline, crystalline in zones. 100% recovery; RQD good.
37.4 to 45.8 ft:	Limestone becoming dark grey, small calcite inclusions and stringers. 100% recovery, RQD good.

48.5 to 51.7 ft: Blue-grey limestone, stringers grading out; fractures more closely spaced. 100% recovery; RQD good.

61.7 to 71.7 ft: Same limestone; rock light grey to tan at 67.2 ft. 100% recovery; RQD fair to good.

71.7 to 81.7 ft: Same limestone; 100% recovery; RQD fair to good.

81.7 to 91.7 ft: Same limestone, 12" fragmental silty zone at 82.3 ft., 14" zone of very closely spaced fractures at 83.5 ft., 5" RQD drop at 86.9 ft., 3" clay seam at 87.9 ft. 85% recovery; RQD good.

91.7 to 101.7 ft: Same limestone, 7" fragmental zone at 93.2 ft., probable clay seam. 91% recovery; RQD fair to good.

101.7 to 111.5 ft: Same limestone; 18" mottled zone at 105 ft. 100% recovery; RQD good.

111.5 to 121.3 ft: Same limestone with some very thin green shaly zones and calcite stringers. 100% recovery; RQD good.

121.3 to 127.3 ft: Same limestone; 3 ft. fragmental zone at 124.6 ft. 96% recovery; RQD poor to fair.

127.3 to 128.5 ft: Dark grey limestone with vertical joint, clay staining. 100% recovery; RQD poor.

128.5 to 138.3 ft: Same limestone, slightly weathered with scattered fractures dipping at 20° 100% recovery, RQD good

138.3 to 146.7 ft: Same limestone; beds dipping more steeply (35° - 40°), 70° fracture at 146.0 ft. 100% recovery; RQD fair to good.

146.7 to 150.0 ft: Same limestone; fragmental from 148.2 - 148.7 ft.

65% recovery; RQD fair. Bottom of hole at 150 ft.

Although the boring data supplied by the Corps of Engineers for Site two (2) seem to indicate favorable foundation conditions, it should be noted that the ridge on which the site is located is flanked by two very large sinkholes. Air photographs taken prior to the construction of RAAP facilities (1937) show the site area is underlain by carbonate rocks north and south of the New River which have been extensively solutioned. Correlation of water table levels with percent recovery and estimated RQD indicate, at least coarsely, that solution activity is presently taking place at the site. At Site one (1), extensive boring investigations may be required to determine the nature and extent of any underground openings associated with these sinkholes. The shallow depth of what appears to be sound rock at Site two (2) will permit the reactor to be founded on bedrock and thus lower the Safe Shutdown and Operating Basis Earthquake design values as compared to Site one (1).

(c) Site-3

The three borings drilled at Site three (3) were laid out in a similar manner to those at Sites one and two. Rock (shale with arenaceous and calcareous zones) was encountered at approximately 20 ft. in each boring. A generalized subsurface profile is described as follows:

<u>Depth</u>	<u>Description</u>
0 to 20 ft:	Silt, trace of clay and fine gravel-sized shale fragments; red, brown and tan mottled, dry to moist and retaining rock structure on weathering (ML).

20 to 27 ft: Shale, reddish-brown and greenish-grey, mottled, thin bedded to medium bedded, partially fragmental, moderately hard, dense to very fine grained, fractures dipping 25-35° 70% recovery, RQD good.

27 to 32.5 ft: Same shale, 81% recovery; RQD good.

32.5 to 39 ft: Same shale; near vertical joint from 35.0 to 37.4 ft., partially fragmental, 100% recovery; RQD good.

39 to 45 ft: Same shale, small calcareous inclusions in core; 100% recovery; RQD fair.

45 to 53.7 ft: Same shale; 100% recovery; RQD good.

53.7 to 61.6 ft: Same red shale, grading sandy, very fine to fine grained, 100% recovery; RQD good, bottom of hole at 100 ft.

61.6 to 72 ft: Same shale, very closely spaced fractures approximately 3" long, 100% recovery; RQD good.

72 to 82 ft: Same shale, blue-grey from 72.3 to 74.3 ft. with calcareous inclusions; 100% recovery; RQD excellent.

82 to 90 ft: Same shale, closely spaced fractures, partially fragmental; 100% recovery; RQD good.

90 to 97.5 ft: Limy breccia, blue-grey, moderately hard, dense to very fine grained, close spaced fractures dipping 30°-40°, slightly weathered, vuggy; 100% recovery; RQD good.

97.5 to 100 ft: Red mottled shale, 100% recovery; RQD good.

Boring and geologic information at Site three (3) indicate that this site probably has the most suitable foundation conditions of all sites studied. There are no problems with solutioning or sinkholes and the depth of overburden may be most suited to the design of the proposed reactor.

Site Ratings

Site 1 - 2

Site 2 - 3

Site 3 - 4

2.2.5.3 Geology. Geologic considerations for nuclear power plants generally deal with faulting and subsurface conditions. In the Valley and Ridge Geologic Province, where RAAP is located, faults are numerous but generally considered not capable of localizing seismic events or surface rupture. However, when faults are found in or near excavations for nuclear power plants, it is necessary to investigate their nature and activity status by performing detailed geologic investigations.

Sites one (1) and two (2) are underlain by a Paleozoic low angle reverse fault which over-rides younger geologic formations. Although the age of last movement of this fault is generally believed to be Late Paleozoic or Early Mesozoic, it will remain the responsibility of the Corps of Engineers to demonstrate the fault's activity status. Site three (3) is located within the Price Mountain window; an ellipsoidal erosional feature in an overthrust sheet whereby the rocks beneath the overthrust are exposed.

As previously noted, karst features, such as sinkholes, pinnacles, caverns, and solution channels, are common in those areas underlain by carbonate rocks. These conditions not only cause engineering problems, but also may cause costly licensing and construction delays. Sites one

and two are underlain by carbonates and thus these problems can be expected to occur at these locations.

Site Ratings

Site 1 - 3

Site 2 - 3

Site 3 - 4

2.2.5.4 Hydrology. Hydrologic considerations used in determining nuclear plant site suitability include flooding potential, water availability, and water quality. Flooding, especially the Probable Maximum Flood (PMF), is one of the primary concerns in the site evaluation process since it may present a serious safety hazard. In terms of water availability for cooling, and considering mechanical draft cooling towers will probably be used, all three sites are equally suitable and should have similar ratings. The quality of available water for each of the three sites should not vary significantly, especially once the modernization and pollution abatement programs are completed at RAAP.

Using Virginia State Route 114 (where it crosses the New River) as a reference point for the estimation of the PMF of +1752 MSL (Ref 2.0-13), Site one (1) is approximately 10 feet above the PMF, Site two (2) approximately 320 feet above the flood level, and Site three (3) approximately 130 feet above the PMF level. There is available area to move site one (1) further uphill thus minimizing the effects of a postulated PMF.

Stroubles Creek, adjacent to site three (3), would also be subjected to flooding during the PMF. Assuming a PMF flood level of +1810 MSL on Stroubles Creek, a plant located at present grade at site three (3) would be approximately 70 feet above this level.

Although sites two and three are well above the Probable Maximum Flood on the New River as determined by the Department of the Army, the rating for site three (3) is slightly downgraded since flooding along Stroubles Creek may affect the steam distribution network, transmission systems, and intake and discharge structures.

Site Ratings:

Site 1 - 3

Site 2 - 5

Site 3 - 4

2.2.5.5 Hazardous Land Use. Because RAAP manufactures propellants and explosives, it quite naturally represents a potentially hostile environment in which to locate a nuclear power plant. Generally, the best source of protection against such hazards is to locate the plant as far as possible from the source materials. The three candidate sites have been evaluated based solely on distance and intervening topography from hazardous areas. Information concerning the types and amounts of hazardous materials produced, stored, or transported in the vicinity of RAAP is only preliminary and, as such, the site ratings should be considered only tentative.

Sites one (1) and two (2) are penalized because they are located in areas which would pose a constant hazard to a reactor due to the manufacture, storage or transportation of munitions. Site three (3) may be subjected to these hazards only occasionally and consequently will have a low probability of accidents due to hazardous land uses. Although site three is immediately adjacent to Virginia State Route 659, and the Norfolk and Western Railroad lies approximately 1200 feet east of the site, the physical geometry of the site area should help to mitigate the effects of an explosion that could take place along either transportation route.

**Site Ratings:**

Site 1 - 2

Site 2 - 2

Site 3 - 3

**2.2.5.6 Construction Access.** The issue of construction access is concerned with the initial difficulty of transporting construction equipment and plant components to a selected site. For the purpose of simplicity, a fixed cost is assumed for the transportation of equipment and material to RAAP and then the three candidate sites are then rated as to their relative cost differences; i.e. construct new roads (and possibly rail facilities) and in what type of terrain etc.

All three candidate locations are near rail facilities and sites one (1) and three (3) have roads nearby. However, sites two (2) and three (3) are located in rough terrain which would probably preclude the use of existing facilities. Site one (1) has limited access via the Norfolk and Western Railroad, Virginia Route 623, and the New River bridge which connects the main manufacturing area with the horseshoe storage area.

**Site Ratings**

Site 1 - 4

Site 2 - 3

Site 3 - 3

**2.2.5.7 Plant Layout.** The plant layout issue is primarily concerned with the amount of land available at each candidate site for locating the proposed facility. A hypothetical plant layout consists of approximately 11 acres for the plant site proper. Another 20 acres will be required for construction facilities and a storage/laydown area. Site three (3), having

the greatest local relief, will be the least suitable of the three candidate locations. Conversely, site one (1) offers the most suitable layout conditions.

#### Site Ratings

Site 1 - 5

Site 2 - 3

Site 3 - 2

2.2.5.8 Cooling Water. The distance to the supply of cooling water and to the ultimate heat sink are important site parameters which affect operating costs and plant efficiency. This issue has been evaluated based on a consideration of not only the distance over which water must be pumped, but also the elevations to which the water must be pumped above the New River.

Considering only the economics of cooling systems, once-through and mechanical wet towers may be used at RAAP. An analysis of these two systems in use at site three (3)\* showed the wet mechanical system to be more economical than once-through cooling. Site two, which is located at a higher elevation above the New River than site three, should also be well suited to mechanical towers. Site one, approximately 90 feet above the New River would probably be suited to a once-through condenser cooling system. Total plant requirements are approximately 2200 GPM (5 CFS) using mechanical wet towers. Once through requirements for any site at RAAP would be approximately 100-125 CFS, just exceeding ten percent of the 7-Day, 10-Year recurrence low flow condition.

\*See Section 3

Section 316(a) of the Federal Water Pollution Control Act (Ref. 2.0-7) generally prohibits the use of once-through systems unless it can be demonstrated by the applicant that the use of such a system would not significantly deteriorate the aquatic environment. This act will probably preclude the use of a once-through system on the New River. Also, legislation was recently passed at the Federal level establishing the New River as a protected, wild and scenic river (Ref. 2.0-11). Another consideration, which tends to separate federal facilities from their commercial counterparts, is that under Executive Orders, and Department of Defense Directives the federal government is charged with providing leadership in protecting and enhancing the quality of the nation's environment.

Based on the foregoing discussion, the use of mechanical wet towers at RAAP would be not only logical, but probably would also be economical for sites two (2) and three (3).

#### Site Ratings

Site 1 - 5

Site 2 - 3

Site 3 - 3

2.2.5.9 Operating Access. Throughout the life of the proposed nuclear plant it will be necessary to transport fuel, wastes, and the workforce to and from the plant site by means of either the existing transportation system or by additions to the existing road and rail network. Since the long term access costs of getting to RAAP proper should be similar for all three sites, the evaluation of operating access is based on the extra costs of added roadway construction and maintenance within RAAP. Another consideration included here is that fuels may have to be transported through populated areas or through potentially hazardous land uses.

Although site one (1) has the most suitable construction access, it is the least suitable for access during reactor operation because all routes traverse potentially hazardous areas. Site two (2) is somewhat better but nevertheless remote from existing roadways and would require a new road in an area with generally poor subsurface conditions. Site three (3) being adjacent to new State Route 659 and the Norfolk and Western Railroad, may provide the most suitable access conditions during plant operation. Also, excepting the road and the east branch of the railroad (over which RAAP does not ship munitions) site three (3) is virtually free of adjacent hazardous land uses through which fuel or plant personnel may have to be transported.

#### Site Ratings

Site 1 - 2

Site 2 - 3

Site 3 - 4

2.2.5.10 Transmission Considerations. An important consideration throughout the lifetime of the proposed facility is the transmission network, whether it be the steam distribution system or the electric power network. The evaluation of the three candidate sites for transmission considerations is based on the distance to the existing central distribution center located at building 400 and also based on the type terrain that these new systems must traverse.

At site one (1) the steam distribution pipeline must cross the New River to building 400 to the southwest, and then go back across the river to powerhouse number two. Sites two (2) and three (3) will require only one river crossing and would have approximately equal amounts of difficulty in terms of terrain.

Site Ratings

Site 1 - 3

Site 2 - 4

Site 3 - 4

2.2.5.11 Meteorology. Ambient and extreme weather conditions are not expected to markedly vary throughout the siting area, therefore there should not be very significant advantages for one candidate site area relative to another. However, for the initial evaluation of the candidate sites the following micro-meteorological criteria have been applied:

- (a) Sites upwind from population centers and dairy farms are less desirable;
- (b) Sites (with cooling towers) upwind from transportation routes are less desirable;
- (c) Comparison of local wind speeds and directions; and
- (d) Topographic influences.

Based on these criteria, sites one (1) and three (3) would be preferable to site two (2) because of their predominantly downwind locations with respect to the Radford/East Radford population centers. Theoretically, site three (3) would have somewhat higher wind speeds than sites one (1) and two (2) because of topographic conditions. This would promote good atmospheric diffusion.

It should be noted that the General Meteorological conditions in the vicinity of RAAP are poorly suited for locating thermal power plants. The ammunition plant is located in a broad valley surrounded by mountains of one thousand feet (1,000 ft) or more of relief which limit the horizontal movements of air masses. These topographic characteristics increase the

frequency of stable atmospheric conditions which, in turn, reduces the diffusion rates of plant emissions. Long, linear valleys (such as those in the vicinity of RAAP) limit the air mass movements to only two directions, up-valley and down-valley, and this subject, downwind population centers to greater doses than would be expected for sites without topographic extremes.

Regional meteorological data reviewed for this report are not site specific; that is they have been collected from a number of sources in southwestern Virginia and are used here for general guidance only. The prevailing winds in the vicinity of the site are generally believed to be from a southerly direction during the summer months and northerly to westerly during the winter season.

Humidities in the vicinity of RAAP are frequently high, particularly in the early morning hours when fog is often observed. Low lying areas near rivers are especially conducive to fog conditions; hence sites one and two can expect a slightly higher frequency of fog than site three. Early morning relative humidities approach 90% during the summer and are approximately 70% in the winter.

#### Site Ratings

Site 1 - 2

Site 2 - 3

Site 3 - 4

2.2.5.12 Aquatic Ecology. The present aquatic environment of the New River and Stroubles Creek in the vicinity of the ammunition plant has been severely degraded due to discharges from towns upstream and from wastes from RAAP. The benthic invertebrate, diatom, and aquatic macrophyte communities sampled in the New River and Stroubles Creek near RAAP show stressed conditions due to pollution (Ref. 2.0-12).

The site ratings for aquatic ecology are based on the concept of "pollution-tolerant" versus "pollution-intolerant" biotic communities. It is generally accepted, where pollution is an unavoidable necessity, to site in areas which are already degraded (pollution-tolerant) rather than in areas that are pristine or nearly so. Stroubles Creek, which receives secondary treated sewage effluent from the Blacksburg-VPI treatment plant, supports a pollution-tolerant community even before it centers the RAAP property. The New River supports a pollution-intolerant community throughout its traverse through RAAP but the number of taxa and density of organisms is significantly reduced when compared to the communities above and below the ammunition plant.

A problem area common to the three candidate sites is the location and subsequent impact of the intake and discharge structures for the proposed nuclear plant. Based on very limited data made available for this study concerning river depths and substrate conditions, it seems that the New River is shallow throughout its traverse of the ammunition plant.

A shallow, rocky river bottom is indicated throughout the area. Water levels fluctuate daily (up to four feet) based on the discharges from the hydroelectric plant at Claytor Lake. Complex intake and discharge mechanisms may be warranted for any of the three sites.

#### Site Ratings

Site 1 - 3

Site 2 - 3

Site 3 - 4

2.2.5.13 Terrestrial Ecology. Prior to its acquisition and development by the federal government, most of the Radford plant area had been

cleared for agricultural purposes. Aerial photographs taken during November, 1937 show site one to be cleared and in agricultural production; site two to be forested but appearing thinned out; and site three under dense forest cover. Similar vegetative patterns exist today with site one mowed, and sites two and three forested.

No rare and endangered species have been reported for the study area and none are expected to use the area for breeding because of the lack of suitable habitat or because of intense human activity. Also, none of the flora reported for the study area are listed as rare or endangered by the Federal Threatened or Endangered List. However, several species of this list use limestone outcroppings as preferred habitats and only a field investigation would delineate their presence.

The site ratings presented for terrestrial ecology are based on the amount of manipulation or perturbation that has occurred at each site. Areas which have been cleared for agricultural or industrial uses would be the least sensitive to the location of a new facility whereas pristine, areas or areas that are nearly so, would be the most sensitive to change.

#### Site Ratings

Site 1 - 5

Site 2 - 3

Site 3 - 3

2.2.5.14 Cumulative Population Density. Historically, the Nuclear Regulatory Commission has encouraged siting nuclear power plants away from densely populated areas regardless of the safety features built into the generating facilities. Cumulative population densities of five-hundred persons per square mile (500 per/mi<sup>2</sup>) for the construction permit date and

one thousand persons per square mile ( $1,000 \text{ per}/\text{mi}^2$ ) during the plant's operating life are the present recommended limits of the Nuclear Regulatory Commission.

The Site Population Factor (SPF), which not only considers the cumulative population to a radial distance of thirty miles, but also accounts for the distance to local population concentrations, is a somewhat less conservative, but probably more realistic assessment of population distribution. An SPF of  $\leq 0.5$  is suggested at the construction permit stage, and an SPF of  $\leq 1.0$  is suggested for the operating life of the plant.

Demographic data (Ref. 2.0-13) furnished by the Department of the Army show the 1970 maximum cumulative population density to be  $318 \text{ persons}/\text{mi}^2$  and the SPF not to exceed 0.2 throughout a radial distance of fifty miles.

Based on a preliminary evaluation of trends in population distribution and growth rates, it is expected that the cumulative population and SPF for the years 1980 (construction permit) and 2020 (decommission) will be within the limits recommended by the Nuclear Regulatory Commission. If for any reason these projections should change, by virtue of a more detailed investigation, and exceed the recommended limits, the technical and economic considerations of site selection close to the ammunition plant should still be considered.

#### Site Ratings

Site 1 - 5

Site 2 - 5

Site 3 -- 5

2.2.5.15 Exclusion Area Radius. The selection of an exclusion area radius by the reactor licensee is required by the Nuclear Regulatory Commission. Within the exclusion area the licensee shall have the "authority to determine all activities... including the removal of personnel and property. The exclusion area must be of such size that doses to individuals at any point on its boundary for two hours immediately following the onset of a postulated fission produce release are less than certain prescribed values" (Ref. 2.0-2). The size of the exclusion area radius, as can be interpreted from the preceding statement, is highly dependent on the engineering design of the reactor, containment, and associated facilities.

Until further data is made available for analyses, it is assumed that the exclusion area radius will be equal to 0.4 miles. This value is considered the minimum radius acceptable to the Nuclear Regulatory Commission. Smaller values may necessitate incorporation of additional safety features into plant design.

Each candidate site has been evaluated and rated based on the amount of RAAP-controlled land within the proposed exclusion area and the nature of activities within the proposed boundaries. The exclusion area of site one lies almost wholly within the boundaries of the ammunition plant. Although the exclusion area includes a portion of land across the river in Montgomery county, it should still be possible to control all activities within the area. There is space at site one to permit expansion of the exclusion area should it be found necessary.

At site two, a parcel of land on the west bank of the New River is included in the exclusion area. Although photorevised (1970) 7 1/2 minute topographic quadrangle maps do not show any residences or other activities

across the river, it may be necessary to demonstrate that this area can be evacuated in a timely manner in the event of a plant accident. The west branch of the Norfolk and Western Railroad, over which RAAP ships most of its munitions and raw materials, as well as a portion of the staff village, are included in the site two exclusion area.

Site three's exclusion area is traversed by Va. Route 659 as well as another branch of the Norfolk and Western Railroad. This should not pose a major licensing problem so long as it can be demonstrated that the Radford Personnel can control access to the exclusion area in times of emergency. Also, there are tentative plans for the construction of a sewage treatment plant along Stroubles Creek in the vicinity of site three. The impact of this activity will have to be assessed when more information is known concerning its location and mode of operation.

#### Site Ratings

Site 1 - 4

Site 2 - 2

Site 3 - 2

2.2.5.16 Low Population Zone. The Low Population Zone (LPZ) is another siting consideration that is directly related to the engineering design of the reactor and plant safety features. The criteria for rating each candidate site at the ammunition plant are the land area which the LPZ includes, the activities within this area, population centers, and possible evacuation routes.

A three mile radius has been used as the exclusion area radius for site selection purposes. The candidate sites, being in close proximity to one another, would have a significant overlap of their respective LPZ's.

However, the LPZ for site two would include a portion of the East Radford - Radford College population concentration.

Site Ratings

Site 1 - 3

Site 2 - 3

Site 3 - 4

2.2.6 Analyses and Recommendations.

2.2.6.1 Weighted Ratings. As previously discussed in subsections 2.2.4.2 and 2.2.4.3, Data Analyses and Rating System, and Weighted Issues, respectively, the prime site is selected based on the ratings of each site characteristic and the weighting of overall importance of the issues studied. The final ranking is achieved by multiplying a site's rating by a relative weighting for that issue. The data for this analysis has been subdivided into three major issues: Initial Engineering Considerations, Operating and Maintenance Considerations, and Environmental and Demographic Considerations. Table 2.2-2 presents a summary of this analysis.

In order to select a site based on the three major issues of Initial Engineering Considerations, Operating and Maintenance Considerations, and Environmental and Demographic Considerations, it is necessary to combine the three issues using a weighting scheme similar to that used for the analysis (Table 2.2-3).

TABLE 2.2-2: Site Identification Analyses

<u>ISSUE</u>	<u>WEIGHT (Ratio)</u>	<u>SITE RATING X WEIGHT</u>		
		<u>Site One (1)</u>	<u>Site Two (2)</u>	<u>Site Three (3)</u>
<u>Initial Engineering Considerations</u>				
Foundation Eng.	4	8	12	16
Geology	3	9	9	12
Hydrology	3	9	15	12
Hazardous Land Use	5	10	10	15
Construction Access	1	4	3	3
Plant Layout	2	<u>10</u>	<u>6</u>	<u>4</u>
TOTAL		50	55	62
NORMALIZED RATING		56	61	69
<u>Operating and Maintenance Considerations</u>				
Cooling Water	5	25	15	15
Operating Access	1	2	3	4
Transmissions	4	12	16	16
Meteorology	3	<u>6</u>	<u>9</u>	<u>12</u>
TOTAL		45	43	47
NORMALIZED RATING		69	66	72
<u>Environmental and Demographic Considerations</u>				
Aquatic Ecology	4	12	12	16
Terrestrial Ecology	3	15	9	6
Cumulative Pop.	1	5	5	5
Exclusion Area	4	16	8	8
LPZ	5	<u>15</u>	<u>15</u>	<u>20</u>
TOTAL		63	49	55
NORMALIZED RATING		74	58	65

TABLE 2.2-3

COMBINED ISSUES ANALYSES

ISSUE	WEIGHT (Ratio)	SITE RATING X WEIGHT		
		Site One (1)	Site Two (2)	Site Three (3)
Initial Engineering	10	560	610	690
O&M Considerations	9	621	594	648
Envir. and Demog.	7	<u>518</u>	<u>406</u>	<u>455</u>
TOTAL		1699	1610	1793
NORMALIZED RATING		65	62	69

The final, normalized values are based on a scale of zero to one hundred (0-100). All of the sites have been penalized because of their geologic and geographic settings along with their location with respect to potentially hazardous areas. Based on an evaluation of the available data and on the preceding analysis scheme, it is believed that all three candidate sites are feasible and can be licensed.

2.2.6.2 Prime Site Recommendation. Site three, at the eastern margin of RAAP, is suggested as the prime site area for this study. This tentative recommendation, included in a draft report entitled Site Identification, had been submitted to the Department of the Army for their review and comment. Briefly, the following comments can be made with regard to the identification of site three as a prime site:

- (a) Site three (3) is the most suitable site in terms of Initial Engineering Considerations. Roughly, this issue may be equated to safety and licensing considerations. As can be seen in the tables, geology and foundation engineering are major factors favoring the use of Site #3.

- (b) Site one (1) is the most suitable site in terms of environmental and demographic considerations. However, it should be noted that all three sites are presently zoned for industrial use. Although this fact will not change the actual environmental impacts of locating at any of the three candidate sites, it would seem that the planned commitment to use these areas for industrial applications connotes a certain acceptance of possible negative impacts by local planning agencies. The acceptance of zoning as a site suitability criterion would favor Site three and serve to revise its environmental ratings upwards.
- (c) The ratings for Site two indicate that this area is the least favorable (relative to Sites one and three) for locating the proposed facility. Its location with respect to the west branch Norfolk and Western Railroad (which is known to regularly carry explosives), its exclusion area, and its location with respect to the Radford-East Radford population centers, along with suspect geotechnical site conditions, all serve to significantly downgrade this site.

### 2.3 EVALUATION OF THE PRIME SITE

#### 2.3.1 Geography and Demography

2.3.1.1 Location. The proposed nuclear process steam/electric generating plant is located approximately 0.6 miles south of the New River in Montgomery County, Virginia. The site lies within the confines of Radford Army Ammunition Plant, (RAAP), approximately 1.25 miles east-northeast of the main administration building, and is adjacent to the newly constructed Virginia State Route 685. The nearest town with a population greater than

1,000 is Radford city (population 11,596 in 1970) located 3.2 miles (popu. 1-  
tion 3.2 miles southwest. Roanoke (population 92,115 lies approximately 30  
miles east-northeast of the site and Lynchburg (population Est. 60,000) 34  
miles east-northeast. The area within the site environs is generally wood-  
lands and very sparsely populated. The coordinates of the proposed reactor  
site are approximately  $37^{\circ}10'57''$  north latitude and  $80^{\circ}31'06''$  west longitude.  
The Universal Transverse Mercator coordinates of the proposed site are ap-  
proximately 4,115,170 mN and 542,740 mE.

2.3.1.2 Site Description. Figure 2-3 shows the location of the  
site along with the location of the proposed reactor, exclusion area bound-  
ary, and present property lines. The ammunition plant presently consists of  
4154 acres of which 2800 acres are used for manufacturing (Ref. 2.0-1).  
The site area is presently zoned for industrial development and plans exist  
for the development of a sewage facility along the main branch of Stroubles  
Creek near the proposed reactor site. This plant will be built on land  
exchanged between the State and the Department of the Army. This exchange  
will result in the acquisition of RAAP property (east of Stroubles Creek)  
by the State, and the State will then give to the Army a parcel of land east  
and southeast of the present TNT area.

2.3.1.3 Exclusion Area. As shown on Figure 2.3, the radius of the  
exclusion area surrounding the proposed plant has been assumed to be equal  
to 2100 feet (0.4 miles). This is a tentative exclusionary radius for the  
purposes of this study.

The boundaries of the exclusion area include portions of newly-  
constructed Virginia State Route 659 and the Norfolk and Western Railroad.  
Other actual and planned activities occurring within the exclusion zone are

the operation of a data processing center for the Deputy Chief of Staff for Logistics (DCSLOG), four structures along the southwestern margin of the zone which are believed to be residences, the finishing area access roads, and a planned municipal sewage treatment facility. Other facilities which are either in the final design or construction stages are the continuous automatic single-base lines (propellants), units #1, #2, and #3, that lie just at the north and northwestern margins of the exclusion area adjacent to the New River. With the exception of the road and railroad, the exclusion area will not be accessible to the public. Emergency plans can be developed to control access along these routes in the event of a plant accident.

2.3.1.4 Low Population Zone. The Low Population Zone (LPZ) for the proposed reactor site has been tentatively set at three miles for the purposes of this study. There is no singular population concentration within the LPZ. Rather, most of the population is distributed linearly along Virginia Route 114. A count of houses within the Low Population Zone utilizing 1970 photo-revised topographic quadrangles reveals a total of 480 structures which may be residences. Assuming all structures are residences occupied by a family of four persons, the total resident population of the LPZ would be 1920 persons. It is conservatively estimated, based on the average population density of Montgomery County, that the resident population within the Low Population Zone will be approximately 2200, 3200, and 4900 persons for the years 1980, 2000, and 2020, respectively. Again, these are very conservative estimates in that a uniform population density has been assumed for Montgomery County. The transient population must be added to these estimates.

2.3.1.5 Cumulative Population. The population projections shown on Table 2.3-1 are based on simplifying analytical procedures. Average population densities for counties and independent cities were tabulated and the area of these cities and counties within an annular ring estimated as fractions thereof. The projected populations for the years 1980 and 2020 were taken from State planning projections.

TABLE 2.3-1

CUMULATIVE POPULATION DENSITY IN THE VICINITY OF  
RADFORD ARMY AMMUNITION PLANT: 1970, 1980, and 2020\*

Distance	1970		1980		2020	
	Population	Density	Population	Density	Population	Density
0- 5 miles	20,430	260	25,000	318	39,000	497
10 miles	57,648	184	59,000	188	109,000	347
20 miles	107,086	83	133,000	106	234,000	186
30 miles	216,095	76	247,000	87	412,000	146

\*Source: Population Projections to 1980, 1990, 2000, 2010, and 2020 for Virginia Counties, Cities, and Planning Districts. Commonwealth of Virginia, Office of the Governor, Office of Research and Information. Richmond, March 1971.

RAAP is located in an area of reasonable demographic isolation. The area is surrounded by mountainous terrain which somewhat restricts the density of agriculture. Historically, the area has been settled by small subsistence farmers resulting in a relatively dense rural population. In recent years the rural population has been migrating to nearby towns and cities such as Blacksburg, Christiansburg, Roanoke, Radford, and Pulaski.

Table 2.3-2 presents these growth trends for the study area.

TABLE 2.3-2  
POPULATION GROWTH IN MONTGOMERY AND PULASKI COUNTIES\*

<u>County/City</u>	<u>1950</u>	<u>1960</u>	<u>% Change</u>	<u>1970</u>	<u>% Change</u>
Montgomery Co.	29,280	32,923	12.4	47,157	43.2
Blacksburg	3,358	7,070	111.0	9,384	32.7
Christiansburg	2,967	3,653	23.1	7,857	115.1
Pulaski Co.	27,758	27,258	- 1.8	29,564	8.4
Pulaski Town	9,202	10,469	13.7	10,279	- 1.8
Radford City	9,026	9,371	3.8	11,596	23.4
Virginia	3,319,000	3,967,000	19.5	4,648,000	17.2
United States	150,697,000	179,326,000	19.0	203,185,000	13.3

\*Source: United States Census of Population, 1950 and 1970, Virginia.

These trends, 1950 to 1970, can be expected to continue. Table 2.3-3 indicates possible future populations, and it is expected that the greatest part of the population increases for Montgomery and Pulaski Counties will occur in the vicinity of Blacksburg, Christiansburg, and Pulaski Town. Radford is an independent city which is expected to grow by as much as thirty percent. None of the towns, cities, or counties in the area surrounding RAAP are expected to experience a population decline.

Cumulative population density within thirty miles of the proposed reactor site is expected to be acceptable throughout the operating life of the facility. That is, in 1980, which is assumed to be the year a construction permit would be issued, the thirty mile cumulative population density would be less than 500 persons per square mile. The projected thirty mile cumulative population for the operating life of the reactor should not exceed 1,000 persons per square mile.

TABLE 2.3-3  
POPULATION PROJECTIONS FOR THE STUDY AREA\*

<u>County/ City</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
Montgomery Co.	47,157	64,600	83,600	102,500	123,200	146,000
Pulaski Co.	29,564	32,500	36,200	40,000	44,600	49,300
Radford City	11,596	12,500	13,200	14,000	14,600	15,000
Virginia	4,648,494	5,415,000	6,284,000	7,222,000	8,217,000	9,350,000

\*Source: "Population Projections to 1980, 1990, 2000, 2010, and 2020 for Virginia Counties, Cities and Planning Districts," Division of State Planning and Community Affairs, Office of Research and Information, Richmond, Virginia, March 1971.

2.3.1.6 Transient Population. Transient population in the vicinity of the proposed reactor site includes variations in population on a seasonal basis and variations in population distribution during the working day, particularly in the Exclusion Area and the Low Population Zone. Preliminary information (Ref. 2.0-4) indicates that there are few seasonal transients in Montgomery and Pulaski Counties. Furthermore, there are few facilities near RAAP which would attract such a population. However, daily transients are numerous in view of the activities at RAAP, the close proximity of Virginia State Route 659 immediately adjacent to the site, and Route 114 which is 4200 feet south of the site. Transient population on the Norfolk and Western Railroad (1200 feet east) and on the New River (3000 feet north) is unknown but expected to be negligible. Table 2.3-4 presents a summary of activities within the Low Population Zone. The number of persons per activity, in most cases, has been estimated but is believed conservative.

TABLE 2.3-4  
ESTIMATED TRANSIENT USE IN THE LOW POPULATION ZONE

<u>Source</u>	<u>Location</u>	<u>Estimated Transient Population</u>
<b>(a) Daily Use of LPZ</b>		
Radford Ammo Plant	1/2-3 miles W	3,866
Filtration Plant	0.85 mi S	20
Belview School	1.0 mi S-SE	200
Pine View Church	1.32 mi S-SE	100
New River Church	1.0 mi S-SW	100
Local Business (Est.)	0.8-3 mi	25
Mount Hope Church	3.8 mi E	100
<b>TOTAL</b>		<b>4,411</b>

TABLE 2.3-4 (Continued)

<u>Source</u>	<u>Location</u>	<u>Estimated Transient Population</u>
(b) <u>Peak Day Use of LPZ</u>		
New River	0.6 mi N	100
Price Mountain	0.5-1.0 mi E	200
TOTAL		300
(c) <u>Daily Population Movement Through LPZ</u>		
Norfolk & Western Railroad	<u>Varies</u>	100
State Highway 659	.08 mi E	15,000
State Highway 114	0.8 mi S	10,000
New River	0.6 mi N	10
TOTAL		25,110
(d) <u>Daily Transient Population</u>		
Total Daily Use		4,411
Daily Population Movement		25,110
TOTAL		29,521
(e) <u>Peak Day Transient Population</u>		
Total Peak Day Use of LPZ		300
Daily Population Movement		25,110
TOTAL		25,410

2.3.1.7 Major Population Centers. The population center, or city closest to the site with a population greater than 25,000 is Roanoke, Virginia. Located thirty-two miles east-northeast, Roanoke had a 1970 census population of 92,115. This represented a loss of over five percent from the 1960 population of 97,110 (Ref. 2.0-15). However, the Roanoke-Salem metropolitan area grew by over thirteen percent during the 1960-1966 period. Table 2.3-5 shows cities with populations greater than 10,000 persons within 50 miles of the site.

TABLE 2.3-5

MAJOR POPULATION CENTERS OF APPROXIMATELY 10,000 PERSONS WITHIN 50 MILES

<u>City</u>	<u>Population</u>	<u>Distance</u>
Roanoke	92,115	32 mi ENE
Salem	21,928	26 mi ENE
Radford City	11,596	7 mi SW
Radford College	3,800	6 mi SW
VPI & SU College	12,000	6 mi NE
Blacksburg	9,200	7 mi NE
Christiansburg	7,857	10 mi SW

2.3.1.8 Land Use and Zoning. The land area within 10 miles of the proposed site lies in portions of two counties: Montgomery and Pulaski counties, Virginia. In Pulaski County, one-half of the area is forested and wood processing industries are important to the general economy. Textile and furniture manufacturing plants, primarily in the Pulaski Town area, are among the largest of the county's activities. The county's fertile farmlands are devoted largely to grazing and dairy farming. Claytor Lake, an Appalachian Power Company hydro-electric reservoir on the New River in the Radford-Dublin area, is the primary recreational attraction of the area (Ref. 2.0-16).

Approximately two-thirds of the Montgomery County area is forested. There are varied mineral resources including the mining of minor amounts of coal along Price Mountain along with aggregate and limestone production. Livestock, grain, and dairying are the primary agriculture interests. Although there are no heavily industrialized centers, there are numerous industrial operations in the Christiansburg-Blacksburg-Radford area. There are two general hospitals, one in Christiansburg and one in Radford, and two state-owned colleges, Virginia Polytechnic Institute and State University

(Enr. 12,000) at Blacksburg and Radford College (Enr. 3,800) at Radford (Ref. 2.0-16).

The total population of the New River Basin, in which Montgomery and Pulaski Counties are located, is approximately 185,000 persons, with an average density of some 61 persons per square mile. The Basin is the least populated major river basin in the State of Virginia because of its remoteness and rough terrain. Twelve percent of the work force of 75,000 persons is employed in farming - approximately twice the national average. Thirty-eight percent of the work force is engaged in manufacturing and approximately fifty percent is engaged in non-manufacturing activities excluding farming. The Radford Army Ammunition Plant, operated by Hercules Powder Company, and the Celanese Corporation near Narrows in Giles County, are the largest employers in the Virginia portion of the New River Basin (Ref. 2.0-16).

To a great extent, topography of the area controls land use patterns. Generally, the steep slopes at higher elevations are forested; the more gentle and cleared slopes of the mountains are used for grazing and dairy-ing; and the gently rolling hills and broad valley bottoms are in cultivation. Population concentrations as well as transportation facilities are located at the lower elevations and along streams and rivers. Table 2.3-6 presents a summary of land and water use acreage for counties surrounding the proposed site.

TABLE 2.3-6

LAND AND WATER USE ACREAGE FOR GILES, PULASKI, MONTGOMERY, AND FLOYD  
COUNTIES, VIRGINIA\*

<u>County</u>	<u>Cropland</u>	<u>Pasture</u>	<u>Forest</u>	<u>Other</u>	<u>Urban</u>	<u>Land Total</u>	<u>Water</u>
Floyd	26,600	83,400	102,000	5,700	3,000	220,700	100
Giles	13,600	47,200	153,200	3,100	3,000	220,100	100
Montgomery	9,600	43,200	64,200	1,800	3,500	122,300	600
Pulaski	25,400	64,100	106,900	6,500	6,700	209,100	4,700

\*Source: New River Basin Comprehensive Water Resources Plan, Volume I Introduction, Division of Water Resources, Commonwealth of Virginia, Richmond 1966.

The area designated as the proposed reactor site is presently zoned for industrial development (Ref. 2.0-17). This area included the entire Radford Army Ammunition Plant from the New River to Virginia Route 114. The area east of the Norfolk and Western where it approached the site is zoned for agricultural use as are those areas north and south of the ammunition plant. That area of Price Mountain east of the site which is not designated as agricultural is zoned for state (Virginia Polytechnic Institute and State University) use (Ref. 2.0-17).

2.3.1.9 Hazardous Land Use. The most hazardous land use in the vicinity of the site is the operation of the Radford Army Ammunition Plant. RAAP manufactures solid propellant for small arms, cannons, and rockets; mortar increments and igniters; assorted explosives and related items. RAAP also processes and assembles components and complete units of rocket motors. Basic manufacturing areas produce large quantities of chemicals, such as nitric and sulphuric acids from raw materials. These chemicals are then

used to make such basic manufacturing ingredients such as nitrocellulose and nitroglycerin.

TNT facilities produce trinitrotoluene by continuous nitration and purification processes. The TNT is then used in the production of high explosives. The recent addition of the TNT facilities to RAAP production capabilities represents a prototype installation and is the first facility of its kind to be constructed in the United States for the continuous manufacture of TNT.

Table 2.3-7 presents a listing of the hazardous materials located in the vicinity of site three: the type of manufacturing facility, explosive limits in pounds, distance from the reactor and calculated pressures from a postulated explosion. The peak reflected pressures are calculated using the methodology presented in NRC Regulatory Guide 1.91, Evaluation of Explosives Postulated to Occur on Transportation Routes Near Nuclear Power Plants. These values for each postulated accident are conservative in that they do not take into consideration the reflective effects of topography and dampening by vegetation.

TABLE 2.3-7  
HAZARDOUS MATERIALS IN THE VICINITY OF THE PROPOSED REACTOR SITE

Facility	Distance From Site (Ft)	Explosive Limits (Pounds)	Peak Reflected Pressure (PSI)*
Automated Single Base Line (E)	1400 NW	140,700	Extreme Fire Hazard
Automated Single Base Line (W)	1800 NW	200,000	Extreme Fire Hazard
Magazine	4200 N	50,000	<1.0
Holding Yard	4800 NW	400,000	1.5

TABLE 2.3-7 (Continued)

Facility	Distance From Site (Ft)	Explosive Limits (Pounds)	Peak Reflected Pressure (PSI)*
Automated Single Base Line (IIIS)	1680 N	241,680	4.0
Automated Single Base Line (III-N)	2120 N	246,680	3.0
TNT Loading Dock	4400 SW	45,000	<1.0

\*Pressures are approximate and based on the assumption that the explosive limits are for TNT or the TNT equivalent of the most energetic propellant in the facility.

Since nuclear power plants in the United States are designed to safely withstand the design basis tornado described in NRC Regulatory Guide 1.76, Design Basis Tornadoes for Nuclear Power Plants, a postulated explosion which produces a peak over pressure (ambient plus explosive event) no greater than the wind pressure caused by the design basis tornado should not cause an accident or prevent the orderly safe shutdown of the plant (Ref. 2.0-18). The dynamic wind pressure recommended for tornado occurring in the vicinity of RAAP (Region I of Regulatory Guide 1.76) is 2.3 psi above ambient conditions. From Table 2.3-7 it can be seen that this value is exceeded for some of the postulated accidents.

Transportation accidents pose similar problems to those of fixed hazardous facilities. Recently constructed state Route 659, a two-lane multi-purpose highway, passes within 360 feet\* of the proposed site. The Virginias Branch of the Norfolk and Western railroad lies approximately 1200 feet east of the site. At the present time there is no information available

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\*Conservatively estimated for accident calculations.

concerning the nature, amounts, and frequency of movements of hazardous materials along these routes. The Norfolk and Western Railroad records such information by sector; that is, information may be obtained not for a single route, but only for a number of routes within a specific area. Thus it is only possible to secure information for the two routes alone the New River (Bluefield and Princeton, West Virginia to Radford, Blacksburg, and Christiansburg, Virginia) but not the individual tracks (Ref. 2.0-19).

The evaluation of accidents occurring along these routes follows the procedure outlined in the Nuclear Regulatory Commission's Regulatory Guide 1.91 (Ref. 2.0-18). It is conservatively assumed that the major accident along the railroad would be the detonation of a 3-boxcar load of TNT and the major accident along the road would be 1/4 truckload\*. These accidents result in a peak positive normal reflected pressure of approximately ten (10) pounds per square inch (psi). Until such time as more detailed and more reliable information is available, the tentative value of ten pounds per square inch (10 psi) should be considered in the design of safety-related structures for the purposes of this study.

Based on a preliminary review of available data, impingement of the containment or other by safety-related structures by aircraft is unlikely at the proposed site. Based upon the data and probabilities of occurrence presented in WASH 1400, it is unnecessary to design for such accidents where airports are at a distance of at least five miles and the approach or take-off patterns do no encompass the air corridor above the site. Table 2.3-8 presents a summary of airport characteristics within fifty miles of the proposed site.

\*Discussion with DOD indicate that RAAP does not ship munitions via Route 659. The 1/4 truckload (10,750 lbs.) is the approximate allowable net weight carried by an eighteen-foot truck. For additional information refer to Appendix 9.

TABLE 2.3-8  
AIRPORTS WITHIN 50 MILES OF THE RADFORD SITE

<u>Airport</u>	<u>Distance and Direction (mi)</u>	<u>Number of Aircraft</u>	<u>Movements/yr (X100)</u>
Blacksburg	6 ENE	35	486
Dublin - New River Valley	10 WSW	13	340
Galax	48 SSW	5	40
Marion - Wytheville Mountain Empire	50 SSW	17	120
Roanoke	35 ENE	108	1490
Bluefield, W. Va.	40 WNW	25	100

Although the Blacksburg Airport is reasonably close to the site, there should be no problem with possible accidents since aircraft land and take-off in a northwest to southeast direction.

### 2.3.2 Meteorology

2.3.2.1 Data Sources. The meteorological data presented in this section is collected from a number of first order and cooperative weather stations in the Southwestern Mountain climatological region of Virginia. Several topical areas are in need of more extensive study and more reliable data in order to satisfy PSAR and ER requirements. The most notable deficiency is the lack of on-site data. A minimum of one year of site-specific data is required to provide acceptable diffusion calculations. It is recommended that a sixty-meter meteorological tower, equipped with wind-temperature- and humidity-measuring instrumentation, be installed nearby or at the site at the earliest date possible so that monitoring and analyses can be initiated. Other deficiencies include the lack of hail and freezing precipitation frequencies;\* the 100-year return period for snow and ice storms;\* and specific data for the ultimate heat sink.

Table 2.3-9 presents a summary of those weather stations contributing data for use in this section.

### 2.3.2.2 Site Area Climatology

(a) General Circulation. The Radford area lies in the Southwestern Mountain climatological region of Virginia. The area is characterized by irregular terrain and significant variations in climatological conditions. The variations are primarily the result of local orographic effects which influence the airflow, temperatures, and humidities. The general climate of the region is one of mild temperatures and well-distributed year-round precipitation. Seasons are distinct, ranging from moderately cold winters

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\* These items would require a review of daily weather records (over a historical 5 year period) from the nearest first order meteorological station.

with occasional snow falls to very warm and humid summers. The regional airflow is predominantly southerly except during the winter when northerly and westerly winds prevail. The principal moisture source for the region is the Gulf of Mexico; Atlantic Ocean influences are seldom experienced because of the nature of the general circulation.

Winter temperatures are moderate except in the higher elevations where harsh conditions can occur. The region lies near the mean track for winter storms and therefore experiences frequent weather variations at that time of year. Storms are sometimes accompanied by strong winds and heavy precipitation, especially in mountainous areas. Topography tends to modify storms by "steering".

Summers are very warm and humid due to the prevailing southerly airflow from the Gulf of Mexico. The airflow is caused by the semi-stationary Atlantic high pressure center which generates a large pattern of clockwise air circulation. Storm centers move across the country less frequently during the summer months and are usually too far north to have a significant effect on southwestern Virginia.

Autumn and spring are transitional periods which produce gradual changeovers from summer to winter and vice versa.

Several factors affect wind speed and direction in the Southwestern Mountain region of Virginia. These include the steering effects due to mountainous topography, semi-permanent pressure systems, and the effects of migrating storms. Table 2.3-10 presents the mean wind velocities and directions for two selected locations in the region. The dominant summertime feature is the Atlantic high pressure system which causes southerly wind across eastern United States. During the winter months, northerly

winds are more common because of the continental high pressure system. Year round wind speeds average about 8 miles per hour; winds during the winter months are slightly stronger. Wind speed and direction can vary significantly between nearby locations due to topographic features. Table 2.3-10 presents a summary of wind speeds and directions for two locations approximately fifty-five miles apart.

A wide range of temperatures have been recorded for the region. Extreme temperatures have ranged from a high of 103° F at Bedford City to a low of -27° F at Blacksburg and Burkes Garden. Also, pronounced variations in temperature have occurred from year to year. Diurnal temperature ranges are highest during the summer when they exceed 20° F at most locations (Table 2.3-11). Table 2.3-12 presents the temperature normals for Roanoke and Lynchburg for the period of record 1941-1970. The mean number of days with freezing temperatures will also vary across the region due primarily to topography. The mean dates with the last freezing temperature in the Spring range from late April to Mid-May; the mean dates with the earliest freezing temperature in autumn range from late September to late October. The mean freeze-free period in the area ranges from about 125 to 210 days. Freeze data are shown on Table 2.3-13.

Monthly and diurnal relative humidity data are presented in Table 2.3-14. Humidities are considerably higher during the summer months when the warm moist airflow from the Gulf of Mexico is commonly experienced. Diurnal variations range from about 20% in the winter to 30% during the summer months.

In the Southwestern Mountain Area, precipitation amounts vary between locations mainly because of differences in topographic exposure. Precipitation occurs as rain, snow, and freezing precipitation. The year round distribution is fairly uniform as can be seen from Table 2.3-15; however, most

locations experience somewhat greater amounts during the summer months due to a relatively high frequency of convective showers (mostly from thunderstorms). Winter precipitation is more commonly the steady type and usually occurs with fronts and storm systems. Extreme amounts of precipitation have occurred during all seasons of the year and are described in Section 2.3.2.3. Snowfall amounts vary from year to year. Mean amounts as observed by recording locations in the region have ranged from about 16 to 25 inches per year. Snow has been observed during the months of October through May, but approximately one half of the annual snowfall occurs during January and February. Table 2.3-16 shows the monthly snowfall amounts as reported by selected reporting stations.

#### 2.3.2.3 Weather Extremes

Heavy precipitation has occurred across the southwestern Mountain Region in the form of heavy rain showers and snowstorms. Rain showers occur as summertime convective activity or as storms of tropical origin. Heavy snows result from moisture-laden storms tracking northerly from the Gulf region during winter months.

Record amounts of precipitation for Virginia have occurred in or near the Southwestern Mountain Region. One area in Nelson County reported a 24-hour rainfall total of 27 inches. This unusually large amount of rainfall occurred with the remnant of hurricane Camille as she tracked easterly across the state. The greatest amount of precipitation recorded at Roanoke for one month and one year is 16.71 inches and 58.79 inches, respectively. The maximum snowfall totals recorded at the same location are 17.4 inches for a 24-hour period and 41.2 inches for a single month. Maximum 24-hour precipitation amounts for selected locations in Southwestern Virginia are

presented in Table 2.3-17. The maximum 24-hour precipitation recorded at Radford City for a 44-year period of record is 9.51 inches. Return periods for precipitation in the vicinity of the proposed site is presented in Table 2.3-18.

Table 2.3-19 presents the fastest mile wind speeds as observed at Roanoke and Lynchburg, Virginia. Extreme winds are most likely to occur from strong extratropical cyclones, hurricanes, thunderstorms or tornadoes. Extratropical cyclones are experienced throughout the year, but severe winds resulting from these storms are likely to occur during the winter months when strong temperature and pressure gradients surround the storm centers. Severe winds from hurricanes are possible but do not usually occur as far inland as the proposed site area. However, local thunderstorms characteristically produce gusty winds and are responsible for most of the strong winds which occur in the region during the summer months. For design purposes, the fastest mile wind at 30 ft. will be assumed to be 130 mph (Ref. 2.0-5).

The most severe winds generally occur with tornadoes, as described in Section 2.3.2.6. Table 2.3-20 presents the return periods for the fastest mile winds for the study region. These figures do not include tornado occurrences but do include severe thunderstorms.

Thunderstorms occur frequently over the Southwest Mountain Region of Virginia. Storms have occurred at all times of the year but are most common during the summer months of maximum surface heating and instability. They may occur as "Air Mass" thunderstorms (a result of locally unstable conditions) or they may occur in association with moving frontal systems as line squalls. The latter conditions usually produces the most severe

storms with violent winds, heavy rains, and hail. Table 2.3-21 presents the mean number of days per month for the occurrence of thunderstorms at Roanoke and Lynchburg.

Storms of tropical origin occasionally reach southwestern Virginia. Most often, they will have dropped to below hurricane intensity since tropical storms rapidly lose energy while traversing landmasses. Therefore, serious wind damage from a tropical storm in this region is unlikely. The major adverse effect from a tropical storm is likely to be from heavy deposits of rain which can cause flooding in the low lying areas. The most memorable example was hurricane "Camille" which produced record breaking rainfall, caused widespread flooding, and caused earthslides in the mountains. Nearly all tropical storms occur during the period of June through October.

2.3.2.4 Local Meteorology. Very little site-specific meteorological data are available for the Radford area. The cooperative meteorological station at Radford records only daily precipitation values. The nearest U.S. Department of Commerce first order meteorological facility is located at Roanoke, 30 miles east-northeast of the proposed site. Because of the complexity of local effects in mountainous areas, meteorological data recorded at Roanoke should be used with caution and only for the purpose of defining regional climatic conditions. Actual site conditions, especially winds and stabilities, cannot be adequately determined from the existing data. The brief descriptions which follow are provided only as estimates of local conditions based on the evaluation of regional data.

The prevailing winds at the site are generally southerly during the summer months and northerly to westerly during the winter season. Average wind speeds are within 7 to 10 mph with the higher velocities occurring during winter and spring. Winds at the proposed site will be influenced

to some extent by channeling effects due to the terrain. Also, slightly higher wind speeds can be expected to occur at the site due to its higher elevation than the surrounding area. This is generally believed to be a favorable site characteristic during ambient conditions.

Temperatures in the vicinity of the site will generally be mild during the winter months and warm - sometimes hot - and humid in the summertime. Frequent changes in air masses, especially during the winter, can produce sharp variations from day to day and also from year to year. Summertime high temperatures will usually average in the mid-eighties; winter low temperatures in the upper-twenties.

Humidities are frequently high, especially in the morning hours when fog is often observed. Low-lying areas along rivers are particularly conducive to fog conditions. Early morning humidities in the vicinity of the site can be expected to approach 90% during the summer and about 70% during the winter.

Precipitation in the site area has varied considerably from year to year. Monthly precipitation recorded at Radford for a 10-year period are shown in Table 2.3-22. The highest monthly amount observed during the period (7.73 inches) occurred in May, 1971; the lowest monthly amount (0.28 inches) occurred in June, 1966. Annual precipitation totals range from less than 30.0 inches to nearly 50 inches. The average annual snowfall for the site area is approximately 28 inches. Snow has been observed during the months October through April.

An estimate of the average seasonal mixing heights at the proposed site can be estimated by comparing the averages for Huntington, West Virginia and Greensboro, North Carolina presented in Table 2.3-23. Mixing heights

in the table are based on "adjusted" data; the computational method used to determine the mixing heights is modified to account for the higher mixing depths experienced during precipitation periods.

As could be expected, the morning mixing heights are considerably lower due to the effects of lower solar radiation; however, the unusually large mean diurnal variation is noteworthy. The site lies in an area where morning mixing heights are among the lowest in the eastern half of the United States and the afternoon mixing heights are among the highest. A major reason for the large diurnal variation is the absence of tempering maritime influences (such as the Atlantic Ocean, Gulf of Mexico, and the Great Lakes). The mixing height variations are also typical of land-locked areas in the western United States.

Atmospheric stability classifications are defined according to Pasquill (Table 2.3-24). A relative frequency distribution of wind directions by stability class is presented for Roanoke, Virginia in Table 2.3-25. As can be determined from this table, neutral or stable conditions occur at Roanoke more than 80% of the time. The highest frequency wind directions occurring during conditions of neutral and stable conditions are from northerly and westerly directions. This is significant from the standpoint of site location since a site located east and south of the nearest population center or the nearest dairy farm would be least likely to disperse airborne radioactivity to these areas.

2.3.2.5 Fogging Conditions. Fog occurs frequently in the Southwestern Mountain Region of Virginia. Heavy fog, defined as fog which reduces visibility to 1/4-mile or less, has been reported on an average of 25 times per year at Roanoke and 40 times per year at Lynchburg. The highest frequencies of occurrence can be expected in river valleys and along low lying

areas. Fog occurs at all times of the year but more frequently during winter and autumn. Winter heavy fogging conditions have the potential of producing ground level icing, a phenomenon which could cause hazardous conditions. Some additional fogging can probably be assumed to occur as a result of using mechanical draft wet towers. Early morning humidities along with the proximity of the site to the New River present a conducive environment for natural fog. The addition of cooling towers may add to this condition.

2.3.2.6 Tornadoes. Probably the most devastating storms known to man are tornadoes. They have occurred in all areas of the contiguous United States, especially in the midwest and southwest. Most often, tornadoes are accompanied by violent thunderstorm activity and line squalls. The Southwest Mountain area of Virginia has not experienced as many tornadoes when compared to other areas east of the Continental Divide. Less than 25 have occurred per 15,000 square miles over a 40-year period of record for this area. Based on these data, there is a 63% chance of a tornado touching the ground somewhere within a 15,000 square mile area in Southwestern Virginia.

The geometric probability of a tornado striking a point in the vicinity of the site is given by the relationship:

$$P_s = \frac{ZT}{A}$$

where

$P_s$  = mean annual probability of a tornado strike

$Z$  = average tornado path area

$T$  = mean number of tornadoes occurring with area "A" per year.

The average path area of a tornado is assumed to be  $0.51 \text{ mi}^2$ . The resulting probability ( $P$ ) for a tornado to occur at a point near the site in any given year is  $2.125 \cdot 10^{-5}$  (mean recurrence interval of 47,059 years) based on a 40 year record of 25 tornadoes in a  $1.5 \times 10^4 \text{ mi}^2$  area.

Following the procedures outlined in Regulatory Guide 1.76 "Design Basis Tornado for Nuclear Power Plants" the regionalized assessment approach (Ref. 2.0-20) identifies the site in Region I as shown in Figure 1 of Wash. 1361 (Ref. 2.0-5). The corresponding design basis tornado characteristics are:

$$v_{\max} = 350 \text{ mph}$$

$$v_{\text{rot}} = 290 \text{ mph}$$

$$v_{\text{trans}}$$

$$\text{max} = 70 \text{ mph}$$

$$\text{min} = 5 \text{ mph}$$

Radius of

$$v_{\text{rot max}} = 150 \text{ ft}$$

$$\text{Pressure drop} = 3.0 \text{ psi}$$

$$dp/dt = 2.0 \text{ psi/sec.}$$

2.3.2.7 Air Pollution Potential. The State of Virginia Air Pollution Control Board has adopted the National Ambient Air Quality Standards as prescribed by the 1970 Amendments to the Clean Air Act. These standards are shown in Table 2.3-26. Primary ambient air quality standards define levels of air quality which are deemed necessary, allowing an adequate margin of safety, to protect the public health. Secondary standards define the levels of air quality deemed necessary to protect the public welfare.

TABLE 2.3-9: SOUTHWESTERN VIRGINIA WEATHER STATIONS

<u>Name</u>	<u>Type*</u>	<u>Distance From Site</u>
Blacksburg	Cooperative	7 mi. ENE
Floyd	Cooperative	27 mi. SE
Rocky Knob	Cooperative	30 mi. SSE
Roanoke	First order	27 mi. ENE
Lynchburg	First order	90 mi. ENE
Meadows	Cooperative	38 mi. SSE
Pulaski	Cooperative	16 mi. SW
Glen Lyn	Cooperative	23 mi. NW
Bedford	Cooperative	64 mi. ENE
Wytheville	Cooperative	40 mi. SW
Burks Garden	Cooperative	54 mi. WSW

\* Cooperative stations furnish data consisting of daily maximum and minimum temperatures along with daily precipitation. First order stations are staffed with National Weather Service personnel. Stations are equipped with recording rain gauges, anemometers, hygrothermographs, as well as supplemental equipment similar to cooperative stations. In addition, data is presented on an hourly basis supplemented by significant weather events.

TABLE 2.3-10: MEAN WIND SPEEDS AND PREVAILING DIRECTIONS

AT ROANOKE AND LYNCHBURG IN MPH\*

<u>Month</u>	Roanoke, Va.		Lynchburg, Va.	
	<u>Wind Speed</u> (1949-1973)	<u>Wind Direction</u> (1959-1973)	<u>Wind Speed</u> (1954-1973)	<u>Wind Direction</u> (1965-1973)
January	9.8	NNW	8.8	SW
February	10.4	SE	9.0	SW
March	10.6	WNW	9.4	SW
April	10.1	SE	9.4	SW
May	8.2	SE	8.0	SW
June	7.0	SE	7.1	SW
July	6.6	W	6.8	SW
August	6.3	SE	6.4	N
September	6.1	SE	7.2	N
October	7.0	SE	7.5	N
November	8.8	NW	8.1	SW
December	9.2	SE	8.0	SW
Annual	8.3	SE	8.0	SW

\*Source: U.S. Department of Commerce, 1973, Local Climatological Data Summaries, National Oceanic and Atmospheric Administration, Environmental Data Service.

TABLE 2.3-11: DIURNAL TEMPERATURES FOR LYNCHBURG AND ROANOKE ( $^{\circ}$ F)

<u>Month</u>	Roanoke (1941 - 1970)		Lynchburg (1941 - 1970)	
	<u>Mean Daily Maximum</u>	<u>Mean Daily Minimum</u>	<u>Mean Daily Maximum</u>	<u>Mean Daily Minimum</u>
January	45.6	27.2	45.8	27.3
February	47.9	28.3	47.8	28.3
March	56.3	34.3	56.2	34.8
April	67.9	43.9	68.1	45.0
May	76.1	52.7	76.6	53.7
June	83.0	60.4	83.5	61.6
July	85.9	64.4	86.1	65.5
August	84.9	63.3	84.5	64.3
September	79.5	56.5	78.7	57.5
October	69.9	45.6	69.0	47.0
November	57.6	35.8	57.3	36.7
December	46.6	28.1	46.9	28.7
Annual	66.8	45.0	66.7	45.9

Source: U.S. Department of Commerce, Local Climatological Data Summaries,  
 National Oceanic and Atmospheric Administration, Environmental  
 Data Service.

TABLE 2.3-12: HIGHEST AND LOWEST RECORDED TEMPERATURES  
AT SELECTED LOCATIONS\*

	Bedford City (H) - (L)	Blacksburg (H) - (L)	Max Meadows (H) - (L)	Wytheville (H) - (L)
Years of Record	<u>13</u>	<u>39</u>	<u>21</u>	<u>28</u>
<u>Month</u>				
January	68 -6	75 -16	75 -11	72 -8
February	73 -6	79 -12	69 -12	73 -6
March	89 10	85 -2	81 2	84 3
April	90 23	89 15	87 19	89 14
May	98 34	91 26	96 26	88 28
June	102 45	99 33	96 34	94 36
July	103 51	100 34	94 45	96 43
August	100 38	98 35	94 45	93 43
September	100 30	78 28	93 25	93 34
October	91 28	86 14	85 17	84 18
November	82 14	79 -1	77 2	78 0
December	70 4	73 -27	70 -12	71 -7
Max./Min.	103 -6	100 -27	96 -12	96 -8

\*Source: U.S. Weather Bureau, 1930, Climatic Summaries of the United States,  
Sect. 94, So. Virginia.

: U.S. Department of Commerce, 1973, Local Climatological Data Summaries, National Oceanic and Atmospheric Administration, Environmental Data Service.

TABLE 2.3-13: FREEZE DATA FOR SELECTED LOCATIONS

\*(1940-1970)

	Average Dates of Occurrence in Spring of:			Average Dates of Occurrence in Fall of:			Average length of freeze-free period (days)
	<u>32° F</u>	<u>24° F</u>	<u>16° F</u>	<u>32° F</u>	<u>24° F</u>	<u>16° F</u>	
Blacksburg	Apr 30	Apr 3	Mar 3	Oct 8	Nov 3	Nov 26	161
Burkes Garden	May 15	Apr 19	Mar 17	Sep 27	Oct 17	Nov 12	135
Floyd	May 4	Apr 3	Mar 13	Oct 6	Nov 2	Nov 22	155
Pulaski	Apr 25	Mar 30	Mar 6	Oct 9	Nov 2	Nov 28	167
Rocky Knob	Apr 24	Apr 2	Mar 8	Oct 23	Nov 7	Nov 28	182

\* or that portion of this period for which data are available.

Source: Water Information Center, Inc., 1974, Climates of the States.

TABLE 2.3-14: MONTHLY AND DIURNAL RELATIVE HUMIDITY MEANS (%)

FOR LYNCHBURG, VA. AND ROANOKE, VA. AIRPORTS

Lynchburg, Va.  
(1964-1973)

Roanoke, Va.  
(1965-1973)

		<u>1:00 AM</u>	<u>7:00 AM</u>	<u>1:00 PM</u>	<u>7:00 PM</u>	<u>1:00 AM</u>	<u>7:00 AM</u>	<u>1:00 PM</u>	<u>7:00 PM</u>
January	-	71	52	59	65	58	50	50	55
February	-	69	49	55	60	64	47	47	52
March	-	71	47	53	61	66	45	45	48
April	-	75	47	52	64	70	46	46	48
May	-	80	51	61	75	76	50	50	56
June	-	83	54	65	83	81	53	53	63
July	-	86	58	71	84	83	56	56	65
August	-	89	59	75	86	86	57	57	68
September	-	88	56	74	85	87	55	55	68
October	-	85	54	70	80	83	53	53	65
November	-	77	50	61	70	74	50	50	58
December	-	75	55	64	68	71	52	52	59
Annual Means	-	79	52	63	74	76	51	51	59

Source: U.S. Dept. of Commerce, 1973, Local Climatological Data Summaries (Roanoke, Va. and Lynchburg, Va.) National Oceanic and Atmospheric Administration, Environmental Data Service.

TABLE 2.3-15: PRECIPITATION NORMALS (inches)  
FOR SELECTED LOCATIONS (1941-1970)

	<u>Radford</u>	<u>Floyd</u>	<u>Burkes Garden</u>	<u>Wytheville</u>	<u>Roanoke</u>
January	2.60	2.84	3.32	2.63	2.74
February	2.67	3.24	3.48	2.75	3.09
March	3.26	3.55	4.06	3.29	3.33
April	2.77	3.41	3.32	2.89	2.80
May	3.21	3.82	3.76	3.51	3.47
June	3.10	3.98	3.83	3.08	3.51
July	4.16	4.81	4.78	4.48	3.74
August	3.42	3.85	3.90	3.84	4.15
September	2.88	4.36	3.11	3.01	3.42
October	2.36	3.14	2.39	2.40	3.19
November	2.25	2.76	3.03	2.34	2.48
December	2.81	3.34	3.44	2.75	3.11
Annual	35.49	43.10	42.42	36.97	39.03

Source: U.S. Dept. of Commerce, 1974, Climatological Data, Virginia,  
National Oceanic and Atmospheric Administration, Environmental  
Data Service.

U.S. Dept. of Commerce, 1973, Local Climatological Data Summary,  
Roanoke, Va. National Oceanic and Atmospheric Administration,  
Environmental Data Service.

TABLE 2.3-16: MEAN SNOWFALL AMOUNTS (inches)  
FOR SELECTED LOCATIONS

	<u>Bedford City</u>	<u>Blacksburg</u>	<u>Brukes Garden</u>	<u>Glen Lyn</u>	<u>Radford</u>	<u>Wytheville</u>
Years:	(27)	(38)	(35)	(16)	(18)	(28)
January	6.	7.4	7.0	6.3	8.1	7.2
February	5.3	5.4	6.0	3.4	4.6	5.2
March	2.3	3.5	5.7	2.8	4.0	3.5
April	0.2	0.8	1.8	0.8	0.7	0.4
May	-	Trace	0.1	-	-	Trace
June-Sept.	-	-	-	-	-	-
October	-	0.1	0.8	0.3	0.1	0.3
November	0.2	1.2	2.1	0.5	0.6	1.5
December	2.4	4.3	4.9	4.3	4.7	5.1
Annual	16.4	22.7	28.4	18.4	22.8	23.2

Source: U.S. Weather Bureau, 1930, Climatic Summaries of the United States, Section 94 - Souther Virginia.

TABLE 2.3-17: MAXIMUM 24-HOUR PRECIPITATION AMOUNTS (inches)  
AT SELECTED LOCATIONS

	<u>Buchanon, Va.</u>	<u>Radford, Va.</u>	<u>Blacksburg, Va.</u>
Years of record:	(48)	(44)	(57)
January	2.40	3.05	1.90
February	1.80	3.20	2.52
March	3.90	2.33	2.05
April	2.42	3.03	2.01
May	5.10	2.72	2.51
June	3.15	5.30	3.84
July	2.90	4.18	3.40
August	4.86	6.90	4.48
September	5.25	9.51	5.90
October	5.68	2.90	3.16
November	2.71	3.68	2.98
December	2.40	2.11	2.27
Maximum	5.68	9.51	5.90

Source: Jennings, A., 1962, Maximum 24-hour Precipitaion in the United States, U.S. Weather Bureau, T.P. #16.

TABLE 2.3-18: RETURN PERIODS FOR PRECIPITATION AMOUNTS (inches)  
FOR THE AREA IN THE VICINITY OF RADFORD, VA.

<u>Return Period</u>	<u>2-day Precipitation</u>	<u>4-day Precipitation</u>	<u>7-day Precipitation</u>
2 years	3.5	4.0	5.0
5 years	4.2	5.0	6.0
10 years	4.9	5.9	7.0
25 years	5.8	6.9	7.8
50 years	6.8	7.5	8.7
100 years	7.0	8.0	9.5

Source: Miller, J. F., 1964, Two to Ten Day Precipitation for Return Periods of 2 to 100 years in the Contiguous United States, U.S. Weather Bureau, T.P. #49.

TABLE 2.3-19: FASTEST MILE WINDS (MPH)

FOR ROANOKE AND LYNCHBURG, VA.

<u>Month</u>	Roanoke, Virginia (1962 - 1973)		Lynchburg, Virginia (1945 - 1973)	
	<u>Speed</u>	<u>Direction</u>	<u>Speed</u>	<u>Direction</u>
January	53	300	45	270
February	40	310	50	180
March	52	320	43	180
April	58	320	43	180
May	46	360	56	360
June	46	280	56	225
July	35	180	43	315
August	37	330	46	045
September	29	310	40	045
October	35	340	41	360
November	52	340	43	315
December	40	300	45	135
Maximum	58	320	56	360

Source: U.S. Dept. of Commerce, 1973, Local Climatological Data Summaries  
 (Roanoke, Va. and Lynchburg, Va.) National Oceanic and Atmospheric Administration, Environmental Data Service.

TABLE 2.3-20: RETURN PERIOD WINDS (FASTEST MILE)  
IN THE SOUTHWEST MOUNTAIN REGION OF VIRGINIA  
(AFTER THOM, 1968)

<u>RETURN PERIOD</u> (YEARS)	<u>MAXIMUM WINDS</u> (MPH)
50	80
100	90

Source: Thom, H.C.S.. 1968 "New Distributions of Extreme Winds in the U.S." Journal of the Structural Division, Proceedings of the American Society of Civil Engineers.

TABLE 2.3-21: MEAN NUMBER OF DAYS WITH THUNDERSTORMS  
AT SELECTED LOCATIONS

<u>Month</u>	<u>Roanoke, Va.</u> (1948 - 1973)	<u>Lynchburg, Va.</u> (1952 - 1973)
January	-	-
February	-	-
March	1	1
April	3	3
May	6	6
June	7	7
July	9	9
August	7	8
September	3	4
October	1	1
November	-	1
December	-	-
Total (per year)	38	41

Source: U.S. Dept. of Commerce, 1973, Local Climatic Data Summaries  
(Roanoke, Va. and Lynchburg, Va.) National Oceanic and Atmospheric Administration, Environmental Data Services.

TABLE 2.3-22: MONTHLY PRECIPITATION AMOUNTS (inches)  
AT RADFORD, VIRGINIA (1963 - 1974)

<u>Year</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Annual<sup>1</sup></u>
1965	3.43	2.74	4.33	2.74	3.42	1.99	5.14	2.25	2.06	3.36	0.78	0.04	32.32
1966	3.59	3.77	1.28	2.53	2.83	0.28	7.44	3.08	5.16	3.81	1.82	3.67	39.26
1967	1.85	1.76	3.24	1.79	3.80	( MISSING )			1.95	1.87	( MISSING )		(MISSING)
1968	( MISSING )	3.07	3.94	1.09	( --- )	( --- )	( --- )	( --- )	( --- )	( --- )	( --- )	( --- )	(MISSING)
1969	1.47	*2.32	2.29	1.60	0.83	4.00	2.37	2.87	4.53	1.39	1.45	6.20	*31.32
1970	1.12	1.29	1.68	3.12	1.33	2.97	4.58	5.20	1.22	2.15	1.65	1.51	27.82
1971	2.25	4.50	2.21	2.45	7.73	3.45	4.85	3.59	4.97	5.39	2.35	0.86	44.60
1972	3.23	3.98	1.83	5.32	4.05	5.94	5.01	2.06	4.86	31.0	5.13	4.25	48.76
1973	2.14	2.45	5.56	4.47	5.51	4.33	2.32	3.98	1.34	4.09	2.41	4.81	43.41
1974	4.35	2.68	3.50	2.27	3.78	2.36	2.37	2.00	3.05	2.09	1.48	2.79	32.82

\* Estimated

Source: U.S. Dept. of Commerce, 1965-1974, Climatological Data, Annual Summary National Oceanic and Atmospheric Administration, Environmental Data Services.

TABLE 2.3-23: MEAN SEASONAL MIXING HEIGHT DATA  
 FOR HUNTINGTON, WEST VIRGINIA AND GREENSBORO, NORTH CAROLINA  
 (1960 - 1964)

<u>Season</u>	<u>Average Mixing Height (meters)</u>	
	Huntington, W. Va.	Greensboro, N.C.
Winter (Dec.-Feb.)		
A.M.	634	480
P.M.	1079	992
Spring (Mar.-May)		
A.M.	721	492
P.M.	1986	1765
Summer (Jun.-Aug.)		
A.M.	338	445
P.M.	1641	1710
Autumn (Sep.-Nov.)		
A.M.	403	343
P.M.	1340	1334
Annual		
A.M.	524	440
P.M.	1511	1450

Source: Holzworth, 1972, Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States, U.S. Environmental Protection Agency.

TABLE 2.3-24: DEFINITIONS OF PASQUILL STABILITY CLASSIFICATIONS

<u>Pasquill Classification</u>	<u>Definition</u>	<u>Temperature Change With Height (<math>^{\circ}</math>C/100 M)</u>
A	Extremely unstable	< -1.9
B	Unstable	-1.9 to -1.7
C	Slightly unstable	-1.7 to -1.5
D	Neutral	-1.5 to -0.5
E & F	Slightly stable to Extremely stable	> -0.5

TABLE 2.3-25: RELATIVE FREQUENCY DISTRIBUTION (%)  
 OF WIND DIRECTION AND STABILITY CLASS AT  
 ROANOKE, VIRGINIA (JAN. 1968 - DEC. 1972)

<u>Direction/ Stability Class:</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E &amp; F</u>
North	0.04	0.37	0.88	3.39	3.38
North-northeast	0.01	0.24	0.52	2.29	1.79
Northeast	0.06	0.21	0.45	1.47	1.47
East-northeast	0.05	0.24	0.32	0.91	0.87
East	0.05	0.31	0.29	1.21	0.91
East-southeast	0.01	0.39	0.50	2.50	1.05
Southeast	0.04	0.44	0.98	4.45	1.42
South-southeast	0.07	0.54	0.95	3.78	1.17
South	0.11	0.93	1.84	3.24	2.08
South-southwest	0.08	0.38	0.39	0.87	1.00
Southwest	0.05	0.47	0.62	1.39	1.19
West-southwest	0.04	0.53	1.16	2.99	1.98
West	0.03	0.49	1.18	4.44	3.47
West-northwest	0.02	0.36	1.11	7.05	4.07
Northwest	0.01	0.22	0.75	6.63	3.60
North-northwest	0.01	0.20	0.55	2.57	2.55
Calms	<u>0.17</u>	<u>0.48</u>	<u>0.41</u>	<u>1.18</u>	<u>3.47</u>
Total (%)	0.65	6.31	11.85	49.17	32.01

Source: U.S. Dept. of Commerce, 1973, "Wind Distribution by Pasquill Stability Class (5) Star Program" National Climatic Center, Asheville, N.C.

TABLE 2.3-26: \*VIRGINIA AMBIENT AIR QUALITY STANDARDS

(Selected Pollutants)

<u>Pollutant</u>	<u>Primary Standard</u>	<u>Secondary Standard</u>
Sulfur Oxides		
Annual Arithmetic Mean 24-hour Concentration	0.03 ppm <sup>#</sup> 0.14 ppm	
Suspended Particulates		
Annual Geometric Mean 24-hour Concentration	75 ug/m <sup>3</sup> 260 ug/m <sup>3</sup>	60 ug/m <sup>3</sup> 150 ug/m <sup>3</sup>
Nitrogen Oxides		
Annual Arithmetic Mean	0.05 ppm	0.05 ppm
Carbon Monoxide		
8-hour Concentration 1-hour Concentration	9.0 ppm <sup>#</sup> 35.0 ppm	9.0 ppm <sup>#</sup>

\* Same as the National Standards

# Not to be exceeded more than one per year

Virginia is divided into 7 Air Quality Control Regions (ACQR) with regional offices and directors. The proposed site is situated in ACQ Region II, an elongated region bordering eastern West Virginia. This area has relatively few monitoring stations, none of which are continuous.

Much of the Montgomery-Pulaski County area is susceptible to inversion layers in the fall. This phenomenon causes the entrapment of not only particulate matter, but also the entrapment of gases generated by automobiles, manufacturing, and fossil fueled generating plants.

### 2.3.3 Hydrology

2.3.3.1 Regional Setting. The proposed site lies within the Upper New River Basin which extends from Bluestone Dam near Hinton, West Virginia, to the headwaters of the North and South Forks of the New River in western North Carolina near Blowing Rock. The New River Basin is part of the Kanawha River Basin which drains approximately 12,200 square miles of West Virginia, Virginia, and North Carolina. It is bounded by the basins of the James and Roanoke River to the east, the Big Sandy and Tennessee Rivers on the west, and the Catawba and Yadkin Rivers to the South. The Kanawha River, into which the New River flows, empties into the Ohio River at Point Pleasant, West Virginia.

Of the 4,634 square miles drainage area in the Upper New River Basin above Bluestone Dam, 770 square miles are in North Carolina, 3,070 in Virginia, and 794 in West Virginia. From its headwaters in North Carolina to Bluestone Dam, the New River has a length of 115 miles. The maximum width of the Basin is 70 miles in the area from rural Retreat, Virginia, to Floyd County-Franklin County line near the headwaters of Little River (Ref. 2.0-16). The principal cities and towns along the course of the New

River are Fries, Radford, Pearisburg, and Narrows, Virginia, and Hinton, West Virginia.

The proposed site is located on the east bank of the New River at latitude  $37^{\circ} 10' 57''$ N, longitude  $80^{\circ} 31' 06''$ W, approximately 10 river miles downstream of the City of Radford. The drainage area of the New River above the site is approximately 3000 square miles with riverbed elevations ranging from 1680 feet at the site to about 3100 feet near the headwaters. Near the proposed site, the New River is an incised, meandering stream with a gentle to moderate slope of approximately 3.6 feet per mile below Claytor Lake.

From North Carolina to Bluestone Dam in West Virginia, the New River flows in valleys ranging in width from 200 to 1000 feet. Many of its banks are formed by very steep bluffs and all of the side slopes of surrounding hills are steep. The nature of the surrounding topography, and the moderate to steep gradients of the New River and its tributaries, produce fast runoff and high velocities in much of the River. The generally rocky bottoms and differential erosion across shale, sandstone and carbonate rocks, combined with fast runoff and high stream velocity, cause a number of rapids and waterfalls. The streambed drops approximately 990 feet from the confluence of the North and South forks in North Carolina to Pearisburg, Virginia, a distance of 157 river miles for an average stream gradient of 6.3 feet per mile. As previously cited, the gradient in the vicinity of the proposed site is approximately 3.6 feet per mile.

The topography within the New River Drainage Basin is generally very rugged, especially along the upper reaches of tributary streams. Much of the upper New River Basin falls within the Valley and Ridge geologic pro-

vince; an area of relatively high mountains, narrow valleys, and occasional steep ravines. Some flood plains and level land are found in the valleys but as the river enters West Virginia the valleys narrow and the topography is dominated by mountainous topography with few areas of level land. There are a number of large and small dams within the Upper New River Basin which are used for flood control, irrigation, and hydro-electric power generation. With respect to the proposed reactor site, the most important of these Dams is Claytor, located approximately 15 river miles upstream. This dam was completed in 1940 for the purpose of providing 75 MW<sub>e</sub> to the Appalachian Electric Power Company. The dam has a structural height of 132 feet, a crest of 1,150 feet, a volume content of 250,000 cubic yards, and a reservoir capacity of 225,000 acre feet. Table 2.3-27 presents a list of other dams upstream of the site along with their owners and intended use. Information concerning their stored volume is presently unavailable. However, each (except Claytor Lake) is believed to be a small impoundment with no major significance to the safety of the proposed site.

2.3.3.2 Local Conditions. At the present time very little data has been made available concerning the channel and flow characteristics of the New River in the vicinity of the Radford Army Ammunition Plant. Volume III of New River Basin Comprehensive Water Resources Plan (Ref. 2.0-21) provides much of the available hydrologic data for the New River with regards to low flow frequencies and average discharges.

Normal channel width in the vicinity of RAAP ranges from approximately 540 feet at the New River Bridge to 270 feet at a point 1000 feet downstream of the confluence of Stroubles Creek with the New River. Channel width at the proposed intake structure, located on the south bank 2200 feet downstream of Stroubles Creek, is approximately 420 feet.

The river depth during normal flow conditions can only be inferred from the literature and from site visits. The presence of small waterfalls and rapids along that portion of the River which flows through RAAP, together with observations of surface turbulence caused by small boulders, indicates shallow depths, probably in the range of two to five feet. There are variations in the water levels along the river due to discharges from Claytor Dam. Bottom conditions along the river are believed to be rocky, consisting of intact bedrock and small boulders.

Table 2.3-28 presents the 1-day and 7-day low flow frequency discharges as adopted in Volume III of the New River Basin Comprehensive Water Resources Plan. The flows at Radford City, Eggleston, and Glen Lyn are based on an analysis of natural and modified flows. Natural flows are those flows not affected by the construction of Claytor Dam in 1939. Modified conditions came into existence after Claytor Reservoir began operating in August 1939. The methodology of analysis used in arriving at these values is presented in the aforementioned reference.

The total water requirements for the proposed reactor utilizing wet mechanical draft cooling towers is 2200 gallons per minute (GPM) which is equivalent to 4.9 cubic feet per second (CFS). Under existing guidelines, the maximum allowable water withdrawal allowable is in the range of 10 to 20 percent of the 7-day, 10 year low flow. Within this range the limiting condition is the biological sensitivity and the stenothermal ranges of aquatic organisms.

Using the figure of 950 CFS (from Table 2.3-28) and assuming the 10 percent limiting condition for the New River, the maximum allowable withdrawal would be 95 CFS. The proposed plant's water requirements are just slightly above 5 percent of the 7-day, 10-year low flow.

The average daily discharge for the New River at Radford (with adjustments for storage in Claytor Lake) over a period of 36 years is 3,714 cubic feet per second. The historic maximum flow of 218,000 CFS occurred during the flood of August 14, 1940 (Ref. 2.0-22); the minimum flow occurred August 25 and 27, 1944 (165 CFS) and the minimum daily flow of 550 CFS occurred August 22, 1911.

Table 2.3-29 presents a summary of discharges at Radford for the water year October 1, 1966 to September 30, 1967. The average monthly temperatures ( $^{\circ}$ F) presented are those recorded at Glen Lyn, Virginia. The lowest and highest water temperatures recorded for the 1966-1967 water year were taken at Stroubles Creek, immediately adjacent to the proposed site. The creek has its head waters near Blacksburg and drains approximately 2 $^{2}$  square miles of the Upper New River Basin. The 7-day, 10-year recurrence low flow can be estimated by multiplying the average discharge per square mile of drainage by the actual drainage area. This gives a low flow of approximately 7.5 cubic feet per second. Using the average monthly discharges (in CFS/ mi $^{2}$ ) from Table 2.3-29, discharges of Stroubles Creek to the New River may range from 50.6 CFS in March to 15.9 CFS in September. Assuming an average value of 1.31 CFS/Mi $^{2}$  for the water year 1966-1967, average flows in Stroubles Creek would be 30.1 cubic feet per second.

2.3.3.3 Water Quality. For the most part, water quality sampling throughout the Upper New River Basin has not been continuous and there is a lack of detailed data concerning the tributaries to the New River. Most information consists of results from infrequent sampling over short periods of time at scattered locations throughout the watershed. Most of the available detailed chemical analyses data is from sampling stations along the

main stem of the New River. At various intervals during the past forty or so years, sampling has been conducted at Galax, Ivanhoe, Allisonia, Radford City, Eggleston, and Glen Lyn. However, data only for Galax and Glen Lyn has been made available for this report. Also, the Department of the Army has made available some limited data concerning water quality at the Radford Army Ammunition Plant.

The quality of water at Galax can be described as being siliceous in nature, soft, and with a minor degree of mineralization. The average concentrations of silica, sodium, and iron are greater at Galax while all other constituents studied are greater at Glen Lyn. The average concentration of nitrates at Glen Lyn is about seven times that of the average for Galax, largely attributable to the greater industrialization above Glen Lyn and in particular, discharges from RAAP. Although the nitrate concentration above Glen Lyn is not presently a health hazard, if certain other constituents are introduced during warm periods of high solar radiation (conducive to greater photosynthetic activity), potentially dangerous algal blooms in reservoirs and streams can be expected.

Increased mineralization below Galax is indicated by a significant increase in dissolved solids and conductivity. This increase can generally be attributed to an increase in industrialization and geologic factors. The entire basin of the New River above Ivanhoe (21 river miles downstream from Galax) lies in an area of crystalline rocks which are highly siliceous. Below Ivanhoe, the New River and its tributaries drain areas of sedimentary rocks - primarily carbonates (limestone and dolomite) with some clastics. Table 2.3-30 presents some water quality data for selected localities along the New River.

With a few exceptions, the quality of surface water obtained from various sources within the area can be generally described as good. The upper reaches of many of the New River's tributaries have water of excellent quality. Many of these streams have less than 50 parts per million (ppm) dissolved solids where they flow across terrain underlain by crystalline metamorphic rocks. Where the waters flow across sedimentary strata, the dissolved solids increase to a range of 50- to 200 ppm, and in areas underlain by carbonate rocks the bicarbonate content of the water increases, resulting in 100- to 200 ppm of calcium carbonate below RAAP (Ref. 2.0-23).

One of the problem areas, in terms of water quality, is Stroubles Creek below Blacksburg. The Virginia Polytechnic Institute-Blacksburg Sanitary Authority has a secondary waste treatment facility discharging into Stroubles Creek. The treatment plant is designed to serve a population of 20,000. However, the estimated combined population of Blacksburg and V.P.I. was approximately 21,000 persons in 1970. Biotic investigations in Stroubles Creek (Ref. 2.0-12) reveal the presence of a "pollution tollerant" aquatic fauna suggesting an already decadent environment.

2.3.3.4 Flooding. The Upper New River Basin has experienced various degrees of drought and flood in the past. Extreme hydrologic conditions, drought and flood, may occur within the same year, however flooding is more likely to occur at any time of the year as opposed to droughts which are commonly seasonal.

The maximum flood of record in the upper New River Basin occurred on August 14, 1940 when a peak flow of 226,000 CFS was recorded at the Glen Lyn gaging station. Gage height has been estimated to be 27.5 feet on this date. Table 2.3-3 presents the momentary peak discharges for four major New River floods at selected localities.

Information concerning the Probable Maximum Flood Level (PMF) has been made available by the Engineering Division, Norfolk District, Corps of Engineers (Ref. 2.0-24). Estimated maximum flood levels for three major floods during the past 98 years (Sept. 1878; July 1916; August 1940) at the confluence of Stroubles Creek with the New River are as follows: September 1878 at 1713 feet MSL\*, July 1916 at 1714 feet MSL, and August 1940 at 1715 MSL. Thus, within the past 98 years there have been three floods within the 1713 to 1715 foot level.

As severe as the maximum known floods may be, it is commonly accepted that in practically all cases, sooner or later a larger flood can, and probably will, occur. Therefore, consideration is given to the Standard Project Flood (SPF) which can be defined "as representative flood discharges that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations" (Ref. 2.0-25). Consideration is also given to the Probable Maximum Flood (PMF) where discharges are the result of the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a geographical area. PMF estimates are usually applicable for the design of spillways of high dams or for other critical structures (Nuclear Power Plants) where an exceptionally high degree of protection is advisable and economically obtainable.

Flooding due to dam failure has not been investigated for this report. The only impoundment that may be capable of causing flooding at the proposed site is Claytor Lake, approximately 15 miles upstream.

\* MSL - Mean Sea Level.

Table 2.3-32 presents estimated flood levels based on the 1940 flood. The proposed site, located at approximately +1860 MSL, should not be subject to flooding due to the PMF.

2.3.3.5 Groundwater. The potential for groundwater production in developed areas of the Upper New River is known to be high. In other areas of the basin where development is scant, it is probable that the groundwater production potential is adequate for many large-scale uses. For the most part, accurate well data are scarce. There is some dependable information concerning well construction, but data relating to production and aquifer characteristics is available for only a few wells. Thorough pumping tests for the determination of drawdown and yield of aquifers are seldom made except where large industrial wells are to be pumped for long periods of time and dependable operating data are required.

Within the site area, groundwater is obtainable from three geologic formations, The Rome (red shale and carbonates), the Elbrook (primarily crystalline dolomite with some limestone), and Maccrappy Formation (shale and sandstone).

The fissile shales of the Rome Formation yield groundwater at the rate of about 10 gallons per minute (GPM). The shales act primarily as an aquiclude, confining water to the carbonate facies of the formation. Where the carbonates occur, springs produce up to 3,000 GPM and 1,000 GPM well yields may be possible.

The Elbrook Formation, consisting of thick-bedded crystalline dolomite and some limestone, is massive with blocky jointing. Groundwater is transmitted along joints, solution channels, fractures, or along bedding planes. Karst features are common. Springs are numerous and, where reported, flows average about 200 GPM. Similar yields can probably be obtained from wells

TABLE 2.3-27: DAMS UPSTREAM FROM THE PROPOSED SITE\*

<u>Name</u>	<u>River Miles Upstream</u>	<u>Owner</u>	<u>Type</u>	<u>Drainage Area (Sq. Mi.)</u>
Stuartdam	108	Fields Mgf. Co.	Hydro	1188
Washington Mills	66	Wash. Mills Co.	Hydro	1581
Byllesby	58	App. Power Co.	Hydro	1733
Buck	55	App. Power Co.	Hydro	1759
Radford Municipal	14	City of Radford	Hydro	337
Claytor	15	App. Power	Hydro	2382

\*Source: New River Basin Comprehensive Water Resources Plan, Vol. I, 1966.

TABLE 2.3-28: 1-DAY AND 7-DAY LOW FLOWS

## 1-DAY LOW FLOW\*

STATION	RECORD (yrs)			Recurrance		Interval		In Years	
		2		10		30			
		CFS**	CFS/Mi <sup>2</sup>	CFS	CFS/Mi <sup>2</sup>	CFS	CFS/Mi <sup>2</sup>		
Galax	1930-65	490	.43	300	.26	250	.22		
Ivanhoe	1930-65	460	.34	255	.19	210	.16		
Allisonia	1930-65	800	.36	560	.25	470	.21		
Radford	1940-65	910	.33	680	.25	620	.23		
Eggleston	1915-65	950	.32	690	.23	650	.22		
Glen Lyn	1927-65	1220	.32	920	.24	740	.20		

## 7-DAY LOW FLOWS

Galax	1930-65	550	.49	340	.30	300	.26
Ivanhoe	1930-65	610	.45	410	.31	350	.26
Allisonia	1930-65	1000	.45	690	.31	590	.27
Radford	1940-65	1100	.40	950	.35	870	.32
Eggleston	1915-65	1200	.41	910	.31	770	.26
Glen Lyn	1927-65	1490	.39	1180	.31	970	.26

\* Source: New River Basin Comprehensive Water Resources Plan, Vol. III,  
Va. Dept. of Conser. and Econ. Devel., Div. of Water Resources,  
Richmond, Va.

\*\* ICFS = 448 GPM

TABLE 2.3-29: DISCHARGE IN CFS, WATER YEAR 1966-1967\*  
AT RADFORD, VA.

<u>Month</u>	<u>Total Discharge</u>	<u>Mean</u>	<u>Max.</u>	<u>Min.</u>	<u>CFS/ Mi<sup>2</sup>**</u>	<u>Temp. (°F)</u>
October	98,073	3,164	13,100	860	1.17	57
November	114,290	3,810	10,200	970	1.34	49
December	132,060	4,260	10,700	1,020	1.55	40
January	156,700	5,055	9,700	1,350	1.85	39
February	118,580	4,235	9,500	1,120	1.53	39
March	192,370	6,205	16,300	1,350	2.20	45
April	83,440	2,781	6,950	1,270	1.12	57
May	122,200	3,942	5,450	2,310	1.41	60
June	81,717	2,724	6,390	916	.98	71
July	67,330	2,172	3,520	1,100	.83	74
August	89,947	2,902	11,700	774	1.06	73
September	57,911	1,930	4,430	877	.69	67

\* Source: Water Resources Data for Virginia, 1967, U.S. Dept. of Interior,  
U.S. Geological Survey, Richmond, Va.

\*\* Drainage Area is equal to 2,748 sq. mi.

TABLE 2.3-30: WATER QUALITY DATA FOR SELECTED LOCATIONS

ALONG THE NEW RIVER

(in parts per million except as noted)\*

	<u>Narrows, Va.</u>	<u>Claytor Lake</u>	<u>RAAP</u>
SiO <sub>2</sub>	5.9	7.3	-
Fe	.05	.06	.33
Mg	8.4	4.4	4.0
Ca	16	8.7	-
Na	3.5	3.5	-
K	1.4	1.2	-
HCO <sub>3</sub>	78	47	-
SO <sub>4</sub>	13	6.8	10
CL	3.5	3.0	5.7
F	0.1	.1	--
NO <sub>3</sub>	2.1	.3	.7
Disolv. Sol.	94	65	66
Hardness	10	1	-
Sp. Cond (μMhos)	169	101	-
pH	7.1	6.6	-

\*Source: New River Basin Comprehensive Water Resources Plan, Vol. IV, 1967  
 Va. Dept. of Conserv. and Econ. Devel., Div. of Water Resources,  
 Rich., Va.

TABLE 2.3-31: NEW RIVER MOMENTARY PEAK DISCHARGES\*

	FLOOD DATES					
	Sept. 30 1959.	April 15 1957	Aug. 14 1940	July 16 1916	Sept. 15 1878	
	Gage Disch.	Height Disch.	Gage Height	Gage Disch.	Height Disch.	Gage Height
Allisonia	64,209	12.05	51,300	10.54	185,000	23.42
Radford City	71,000	18.64	54,400	15.33	218,000	35.96
Eggleston	70,600	20.85	55,200	17.90	215,000	41.16
Glen Lyn	66,000	--	66,700	13.57	226,000	27.50

TABLE 2.3-32: PROBABLE FLOOD LEVELS AT SELECTED LOCALITIES  
ALONG THE NEW RIVER\*

<u>Flood</u>	<u>Bridge Va. 114</u>	<u>New River Bridge</u>	<u>Stroubles Creek</u>
Est. PMF	+1754	+1739	+1735
Est. SPF	+1736	+1723	+1720
1940 Flood	+1727	+1717	+1715
100 Year Flood	+1725	+1714	+1712
50 Year Flood	+1721	+1709	+1707
25 Year Flood	+1716	+1704	+1702

\*Source: Letter, 25 July 1975, Mr. Charles Hicks, Hydrology Section,  
Engineering Division, Norfolk District Corps of Engineers,  
Norfolk, Va.

throughout most of its outcrop area. At RAAP (on the horseshoe) a 12-inch diameter well was drilled to a depth of 380 feet. The yield was 200 gallons per minute with a drawdown of 26 feet for a specific capacity of 7.69 (GPM per foot of drawdown).

The Price (sandstone) and Maccrady (shale) formations which underlie the site are unimportant as major aquifers. The Price formation will probably produce a few GPM at selected localities.

#### 2.3.4 Basic Geology and Seismology

2.3.4.1 Regional Physiography. The Appalachian Highlands, in which the site area is located, includes four natural divisions: the Piedmont Upland to the southeast, the Blue Ridge Province, the Valley and Ridge Province, and the Appalachian Plateaus. The Piedmont Upland, a gently rolling surface, rises from about +200 feet MSL at the Fall Zone to about +500 feet MSL in the vicinity of the Potomac River at the southeast base of the Blue Ridge Mountains, and about +1500 feet MSL towards the Virginia-North Carolina state line. The Blue Ridge province includes the mountains bearing its name along with other mountainous area west of and adjacent to the Piedmont Upland. This is the highest area east of the Rocky Mountains and culminates in Mount Mitchell, North Carolina (6711 ft).

The Appalachian Valley, or Valley and Ridge Province, includes the relatively narrow belt of tightly folded and faulted rocks between the Blue Ridge Province and the eastern escarpment of the Appalachian Plateaus. The escarpment is almost continuous from Pennsylvania to Alabama and bears different names in different places.

The Appalachian Valley is a continuous physiographic feature which extends from central Alabama northeastward to central Pennsylvania, and dis-

continuously as far north as the St. Lawrence Lowland. Its width varies from a narrow 14 miles at the New York-New Jersey border to 80 miles along a line between Harrisburg and Williamsport, Pennsylvania. The province has often been called the "Folded Appalachians" but the name is apparently a misnomer since folding extends beyond the province both east and west.

The Valley and Ridge province displays many distinctive features such as marked parallelism of ridges and valleys, generally in a northeast-southwest direction; conspicuous differential weathering manifested in topographic forms; a trellis drainage pattern with a few major transverse streams; suggestion of several cycles of erosion and uplift; and a number of water and wind gaps.

The Appalachian Valley can be subdivided into two subsections; the Valley and Ridge sub-physiographic province on the east which is more Valley than Ridge; and the Ridge and Valley portion to the west which is dominated by tight, ridge-forming folds.

2.3.4.2 Site Physiography. The most dominant physiographic feature in the vicinity of the proposed site is Price Mountain. The site is located on the eastern end of this east-west trending anticline. Maximum local relief is approximately 750 feet from the New River (el. 1700) to the highest points along Price Mountain. The New River, along with many of its tributary streams, is incised into the rocks over which it flows. The result of this down-cutting action is the formation of steep bluffs (200 feet) along portions of the River. Much of the area adjacent to the New River is underlain by limestone and dolomite and is highly solutioned. Sinkholes, pinnacles, and disappearing streams are common. Prominent ridges and hills are common where sandstone and shale formations are present.

The site area is drained by first and second order streams which empty into the New River.

2.3.4.3 Regional Geology and Tectonics. The regional geology and tectonics of the Southern Appalachians is complex and has been the subject of many classical studies. South of its bisection in the vicinity of New York City, the Appalachian foldbelt is continuous to Alabama. Throughout this distance it borders the Paleozoic craton deposits to the northwest with a well-defined topographic and structural front (the Valley and Ridge Province), along which steep folds and reverse faults end abruptly, giving rise to more open structures beyond (Appalachian Plateau).

The Southern Blue Ridge Geologic Province consists of a complex assemblage of plutonic gneisses and intricately deformed and metamorphosed sedimentary and volcanic rocks. This complex has been intruded by various types of igneous rocks of Precambrian and Paleozoic age. Granites and gneisses form the oldest rock types dating back, approximately one billion years before present. However, shists, gneisses, and amphibolites, presumably of volcanic and sedimentary origin, comprise a large portion of the Blue Ridge Province. These rocks are believed to be somewhat younger than their granite counterparts; principally of late Precambrian age (Ref. 2.0-26).

The Blue Ridge Province is separated from the Piedmont Province to the east by the Brevard Shear Zone, a northeast trending zone of intense deformation and shearing. To the northwest, a great reverse fault separates the Blue Ridge Province from the Valley and Ridge Province of the Appalachians. The closest approach of the Blue Ridge Province to the Site is approximately 12 miles.

The rocks to the west of the Blue Ridge Province - the Valley and Ridge Physiographic Province - are generally characterized by numerous closely spaced folds and many low angle reverse faults. The fold axes and the strike of the faults generally parallel the trend of the Province-Northeast to Southwest. Thrusting movement along the faults is nearly always towards the northwest and many of the folds are oversteepened or overturned to the west on their west flanks, suggesting strong compressional forces from the southeast. Within the province, folds become more numerous and more intense (tighter) towards the southeast. Also, the frequency of thrust faults becomes higher towards the southeast (Ref. 2.0-27). The maximum thickness of the sedimentary rocks in the province is believed to be about 30-35,000 feet; in the vicinity of Radford they are at least 12,000 feet thick. However, these thicknesses do not represent a complete 12- to 35,000 foot time stratigraphic sequence; rather, the section has been repeated in many areas because of overthrusting.

The maximum amount of movement along these thrust sheets seems to have occurred along the Pulaski thrust sheet. It has been described as having a horizontal displacement of eight or more miles and a minimum stratigraphic separation of almost two miles (Ref. 2.0-28).

2.3.4.4 Geologic History. A brief geologic of the Southern Appalachians is presented to provide background information on the origin of the present tectonic setting.

At the beginning of Phanerozoic time, approximately 570 million years ago, the present Appalachian Highlands (the Appalachian Plateau, Valley and Ridge, Blue Ridge, and Piedmont Geologic Provinces) was occupied by a long,

broad trough of varying depths which extended from the Gulf of St. Lawrence to the Gulf of Mexico. This water-filled trough, generally called the Appalachian Geosyncline,\* ranged in width from a few miles at its northwestern-most end to at least 150 miles in the present area of southwestern Virginia. To the east of this basin was a rugged mountain range generally referred to as "Appalachia"; to the west of the geosyncline lay the continental borderland or "craton" as it has come to be named. The geosynclinal trough is believed to have been deep adjacent to Appalachia, similar to "deeps" adjacent to island archs today, and gradually became shallow towards the craton.

From the Appalachia Upland, debris-laden rivers debouched to the geosynclinal sea and deposited their sediments - now known as those rock composing parks of the Valley and Ridge Province.' At the same time the continental interior or craton was an area of very low relief undergoing very slow erosion. At various times the sea spread across parts of the craton, and, because this sea was believed to be warm and shallow carbonates and bittering salts were deposited. Some of these carbonates and salts were also deposited in the deeper parts of the geosyncline during periods of aridity in Appalachia. Regional fluctuations of climate, tectonism, and volcanism are responsible for the sometimes alternating units of clastics and carbonates.

By Pennsylvanian time, approximately 300 million years ago, the geosyncline was almost entirely filled with materials eroded from Appalachia or from carbonates precipitated from sea water. It was at this time that

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\* The term geosyncline is used here to infer that a large region has a generally downwarped structure, though it may be modified by other geosynclinal structures.

much of the coal mined today in Pennsylvania, West Virginia, and Kentucky formed in shallow swampy seas.. By the end of Pennsylvanian time the geosyncline had probably subsided at least 40,000 feet, due in part to the mass of sediments deposited in it during the prior 300 million years. By the close of the Pennsylvania period the trough had stopped its subsidence and a new geologic cycle was initiated.

A compressive force began to thrust northwestward, folding the sedimentary rocks which had been recently deposited. The lateral forces of compression acting on the rocks at first caused plastic deformation - bending and warping into tight folds - and then brittle deformation - thrust faulting. As these forces became more intense, a mountain system appeared where there was once sea. Blocks of rock were thrust over one another in succeeding episodes of faulting. The geosyncline was uplifted into a mountain range of folded ridges and the eastern borderland, once called Appalachia, was compressed and uplifted also.

By the beginning of the Mesozoic era, approximately 225 million years ago, the uplift was completed and erosional processes became the dominant factor. The compressional forces of the Paleozoic era were reversed and extension became prominent along the eastern margin of the New Appalachian Mountain Range. Extension caused normal faulting and created what is known today as the Triassic Basins. As these basins sank, they were filled with clastics being eroded from the newly formed mountain ranges. At first the clastics were coarse, giving rise to some of today's basal Triassic Conglomerates. Later, as the streams stopped down-cutting and lost their transportational energy, sand, silts, and clays began to be deposited in these faulted basins.

During the Mesozoic and Cenozoic (beginning 65 million years ago) eras, the New Appalachian mountains periodically underwent episodes of epeirogenesis - broad movements of uplift which affected large parts of the mountain region. During these positive movements, streams renewed their down cutting and dissection of the land. The result of each uplift was the creation of peneplanes - land surfaces worn down by erosion to a nearly flat or broadly undulating plain. Remnants of these plains may be seen today occurring as terraces or plateaus of similar elevation throughout the Valley and Ridge Province.

2.3.4.5 Site Geology. Although there are no small scale geologic maps available that cover the site area, the geology can be inferred with a reasonable amount of assurance by reviewing regional geologic maps and references. Figure 2-4 shows the site location relative to the geology of the Blacksburg-Radford Area.

Hergenroder (Ref. 2.0-28) describes fourteen formations which crop out in the Radford area, ranging in age from Early Cambrian to Early Mississippian. Table 2.3-23 presents seventeen local formations along with a brief description of each. The order in which they are presented reflects their time-stratigraphic relationships, although they may not have the same relationship at the site due to faulting.

2.3.4.6 Tectonic Structures. The site is located within the Blacksburg synclinorium, a long and broad downwarped structure extending southward from the town of Blacksburg to the vicinity of Pulaski. The north limb is well exposed along the New River Gorge between Eggleston, Giles County, and Belspring, Pulaski County. The southeast limb of the syn-

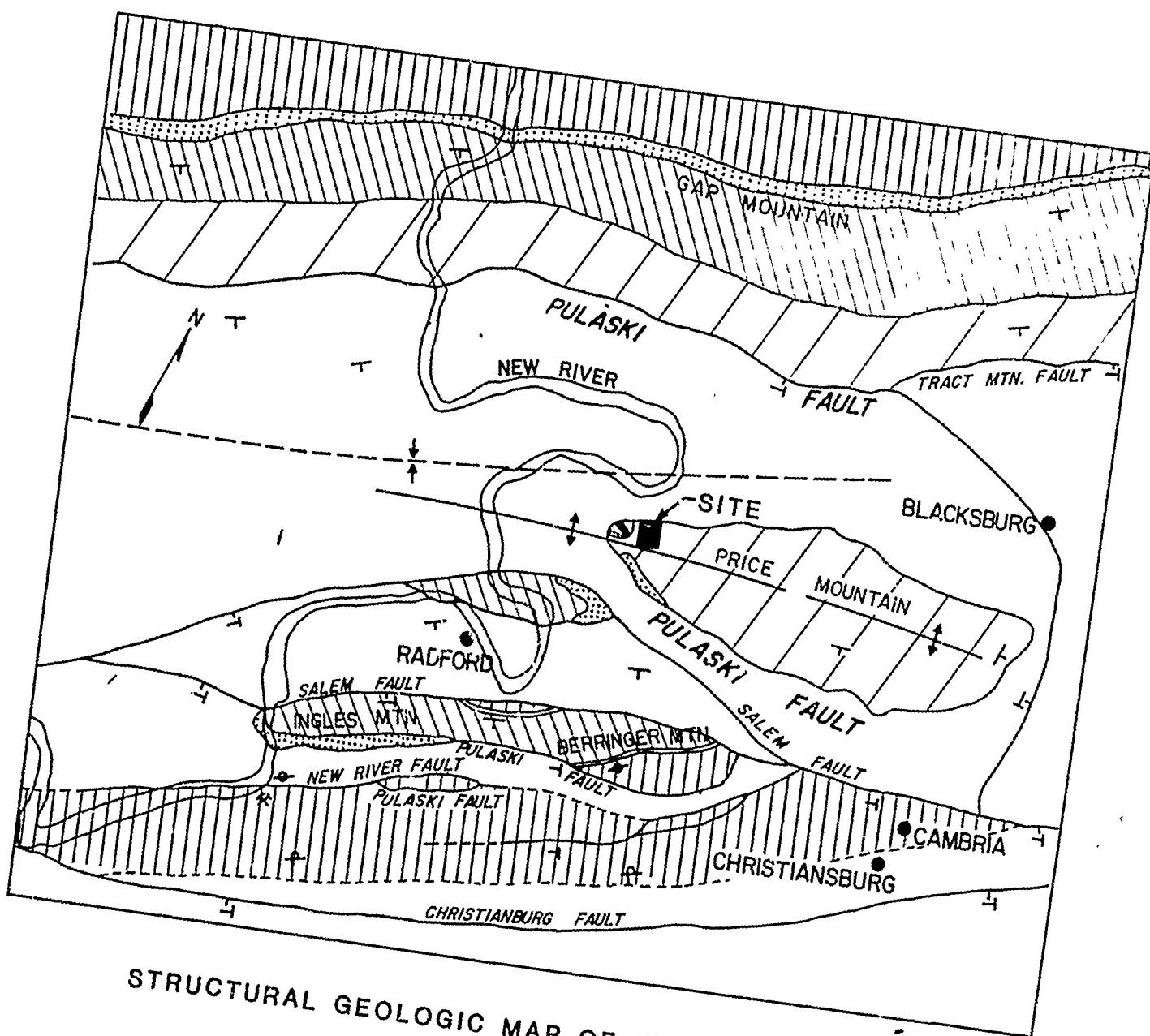
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\* Window: A circular or ellipsoidal erosional break in an overthrust sheet whereby the rocks beneath the overthrust are exposed.

clinorium is well exposed in a series of five windows created by reverse and overthrust faulting. Cooper (Ref. 2.0-29) suggests that the major down-fold began to take form in Ordovician time as a consequence of strong differential downwarping of the Paleozoic seafloor. The downwarping continued into Mississippian time, and the thrust faulting of the Pulaski and May Meadows thrust blocks began. The fact that downwarping of the synclinorium and thrust faulting of Lower Paleozoic Rocks were penecontemporaneous is indicated by the undulating and folded nature of the Pulaski fault contact. Cooper further suggests that mechanics of thrust faulting may be due to active underthrusting of the depositional syncline since it was already undergoing negative movements.

As can be seen from Figure 2-4, faulting is common throughout the site and near vicinity. The contact between the rocks underlying Price Mountain (The Price and Maccrady Formations) and the rocks of the surrounding area (Cambrian Rome and Elbrook Formations) is due to faulting. At this location, the Cambrian Limestones and dolomites of the Pulaski thrust sheet overrode the younger rocks of Price Mountain and were subsequently folded. These faults are within a few hundred feet of the site.

Other major faults in the area include the Saltville thrust fault seven miles to the northwest in Giles County; the Salem thrust fault one and one-half miles south of the site; the Claytor thrust fault five miles south of the site; and the May Meadows thrust, six miles south-southeast of the site. Many of these fault contacts are repeated throughout the area due to low angle thrusting and erosional windows. None of the faults are believed to be active today or capable in terms of Nuclear Regulatory Commission Criteria (Ref. 2.0-2).



STRUCTURAL GEOLOGIC MAP OF THE SITE VICINITY

SYMBOLS:

- T STRIKE & DIP
- T THRUST FAULT
- T OVERTURNED BEDS
- ↑ ANTICLINE
- ↓ SYNCLINE

0 1 2 3 4 MILES

KEY:

[Hatched pattern]	MISSISSIPPIAN
[Diagonal hatching]	DEVONIAN
[Dotted pattern]	SILURIAN
[Vertical hatching]	ORDOVICIAN
[Horizontal hatching]	CAMBRIAN

REFERENCES:  
 COOPER, B.M. 1961, GRAND APPALACHIAN EXCURSION,  
 VPI ENGR. EXTENSION SERIES GEOLOGICAL GUIDEBOOK  
 NO. 1,

FIGURE 2-4

2.3.4.7 Seismology. The central Appalachian region of Virginia, East Tennessee, and West Virginia is characterized by a moderate amount of low-level seismic activity, generally of intensity\* V-VI with a few intensity VII's and two intensity VIII's.

The temporal and spatial relationship of earthquake occurrence in the Central Appalachians has been fairly constant since 1870, with an average of 12 seismic events per 10 year period (Ref. 2.0-30). The seven earthquakes which occurred during 1897 is the maximum number recorded for any one year of record.

The proposed site lies at the Northeastern limit of the Southern Appalachian Seismic Zone which extends from Western Virginia through East Tennessee and Western North Carolina to Central Alabama. This zone covers approximately 62,500 sq. miles. Table 2.3-34 presents the number of earthquakes by decade and by Intensity for the Southern Appalachian Seismic Zone, and Table 2.3-35 presents those earthquakes within two hundred (200) miles of the Radford Army Ammunition Plant.

Although the number of events experienced by this area appears to be high from the Southeastern United States, it must be noted that few events of seriously destructive proportions have occurred. The region can be termed sparsely populated, especially in the mountainous areas, but cities of good size (Blacksburg, Radford, Roanoke, Bluefield) are in close proximity and historic reports are found describing many of the events, indicating some degree of reliability of the historical record.

Precise determinations of epicenter locations, foci, and magnitudes have been available only since the installation of modern seismographs. As

\* Modified Mercalli Intensity Scale of 1931.

a result, few earthquakes have been instrumentally recorded and most earthquakes must be subjectively rated in terms of a damage scale (Modified Mercalli Intensity Scale of 1931, Table 2.3-36).

The May 31, 1897 Giles County event, rated on the Mercalli Scale as Intensity VIII, is believed to be the strongest earthquake to occur within two hundred miles of the site and will be the controlling earthquake for all critical seismic designs. Earthquake history of the United States (Ref. 2.0-31) describes the May 31, 1897 event in the following manner:

"Rumbling was heard at various times between May 3 and 31. On May 31, there was a strong shock felt from Georgia to Pennsylvania and from the Atlantic coast to Indiana and Kentucky. It was felt most strongly at Pearisburg, Giles County, Va., and is generally known as the Giles County Earthquake. Old brick houses and chimneys were cracked, and bricks were thrown down from chimney tops. There were fissures in the ground and small landslides in places where they were easy to start. At the Narrows, it was claimed that a motion like the ground swell of the ocean was observed. Large rocks rolled down the mountains. There were loud sounds, compared by veterans to that of siege guns. At Wytheville, bricks were thrown from chimneys; some were cracked and out of place. Chimneys were shaken down at Bedford City, Houston, Pulaski, Radford, and Roanoke. In Raleigh, North Carolina, two shocks were reported that lasted 30 seconds and chimneys thrown down. Chimneys were also damaged or down at Bristol and Knoxville, Tennessee, and Bluefield, West Virginia. These tremors continued until June 6. The main, May 31, shock was also felt at Spartanburg, South Carolina and Cincinnati, Ohio."

Although it appears that the epicenter was located in the vicinity of Pearisburg, near the boundary of the Appalachian Plateau and Valley and Ridge Provinces, there are no indications of a controlling structural feature to which the earthquake can be attributed. This structural boundary, the Appalachian Structural front, generally marks a sharp transition between very gently folded rocks on the northwest and intensely folded and faulted rocks on the southeast. However, this is only a change in the intensity of folding and faulting from east to west and not a major structural discontinuity.

The preliminary design value for the Safe Shutdown Earthquake is determined by locating the Giles County Intensity VIII event at the site. The determination of the accelerations caused at the site is the mean acceleration plus one standard deviation. Trifunac and Brady (Ref. 2.0-32), for an Intensity VIII earthquake, give a mean horizontal acceleration of  $166.76 \text{ cm/sec}^2$  and a standard deviation of  $84.06 \text{ cm/sec}^2$ . Thus, the accelerations on bedrock which could be expected at the site due to a recurrence of the May 31, 1897 event should not exceed .25g. Until further studies are performed, and in the interest of conservatism, it is recommended that a design value of .25-to .30g be considered. Coulter, Waldron, and Devine (Ref. 2.0-33) also suggest for an Intensity VIII the value of .25g for sites with average to good bedrock conditions. A value of 0.3g is used until additional studies indicate a lower value.

Present Nuclear Regulatory Commission Guidelines (10 CFR 100, Appendix A) state that the maximum vibratory ground acceleration from the Operating Basis Earthquake shall be at least one-half the maximum vibratory ground acceleration of the Safe Shutdown Earthquake. Should a nuclear power plant

TABLE 2.3-33: LOCAL GEOLOGIC FORMATIONS

1. Quaternary Deposits:

Valley alluvium; talus slopes; local travertine deposits along streams.

2. Mississippian MacCrady Shale:

Red shale and mudstone, with a few interbeds of siltstone and sandstone. Shale, siltstone, and mudstone are greenish-grey to reddish-brown on fresh surfaces.

3. Mississippian Price-Pocono Formation:

Sandstone and greywacke, greenish-grey to brown, some shale; contains 4-foot Merrimac coal bed about 150 feet below top of unit.

4. Devonian Black Shale:

Black, extremely fissile shale; a few lenses of siltstone and calcareous shale grading into shaly limestone.

5. Devonian Huntersville Chert:

Black and greyish-tan chert with some sandy zones; medium to thin bedded.

6. Silurian Clinch Sandstone:

Well-indurated quartz sandstone and orthoquartzite; light-grey to black on fresh surfaces.

7. Ordovician Martinsburg Formation:

Siltstone, shale, and shell limestones; siltstones and fine grained sandstones found in upper part of formation.

8. Ordovician Liberty Hall Formation:

Dark grey to black limestone, fine grained and thin-bedded.

9. Ordovician Fetzer Limestone:

Medium- to dark-grey limestone that is coarse grained and thick bedded. Contains argillaceous and silty material in once centimeter thick beds.

10. Ordovician Lenoir Limestone:

Composed of three distinct types of dark-grey to black limestone. Lowermost unit is the Mosheim member, a thick bedded, dense limestone that breaks with conoidal fractures.

11. Knox 1 Cambro-Ordovician Knox Dolomite Group:

Medium- to very dark gray dolomite with chert and some sandstone.

12. Cambrian Conococheague Formation:

Chiefly fine-grained bluish-grey limestone, most of which contains the laminations of argillaceous material; some grey dolomitic limestone and dolomite.

13. Cambrian Elbrook Formation:

Thin-bedded to shaly dolomite; considerable thicknesses of dolomitic limestone and argilaceous limestone also present.

14. Cambrian Rome Formation:

Chiefly composed of red, greenish-grey, and light brown shales. Considerable thicknesses of siltstone, limestone, and dolomite are also present. However, red shale is most conspicuous. Occurs near site as dolomite and limestone.

15. Cambrian Hampton Formation:

Conformably overlies the Unicoi, contact indistinct; mainly consists of shales and siltstones with some fine-grained sandstone and coarse-grained sandstone resembling those of the Unicoi.

16. Lowest Cambrian Unicoi Formation:

(Also considered Precambrian by some). Consists of medium- to thick-bedded feldspathic sandstone with interbedded quartz sandstone, siltstone, and shales. No fossils have been reported from the Unicoi which is in part the basis for its problematical age relationship.

TABLE 2.3-34: NUMBER OF EARTHQUAKES BY DECADE AND BY SIZE  
FOR THE SOUTHERN APPALACHIAN SEISMIC ZONE\*

DECADE	Intensity							DECADE TOTALS
	?	III	IV	V	VI	VII	VIII	
1770-79	-	-	-	1	-	-	-	1
80-89	1	-	-	-	-	-	-	1
90-99	1	-	-	-	-	-	-	1
1800-09	-	-	-	-	-	-	-	0
10-19	1	-	-	-	-	-	-	1
20-29	3	-	-	-	-	-	-	3
30-39	1	-	-	-	-	-	-	1
40-49	1	-	-	1	-	-	-	2
50-59	4	1	-	-	1	-	-	6
60-69	-	-	-	-	-	-	-	0
70-79	1	-	4	2	-	1	-	8
80-89	9	-	4	3	-	-	-	16
90-99	2	-	1	3	2	-	1	9
1900-09	-	-	-	4	-	-	1	5
10-19	1	6	5	8	1	3	-	24
20-29	5	-	-	5	1	2	-	13
30-39	1	1	3	3	1	-	-	9
40-49	2	4	6	2	1	-	-	15
50-59	2	-	10	3	8	-	-	23
1960-69	7	1	6	6	1	-	-	21
Column Totals	42	13	39	40	17	6	2	159

Source: Bollinger, G.A., 1973, Seismicity of the Southeastern United States, Bull. Seis. Soc. Amer., Vol. 63, No. 5.

TABLE 2.3-35: EARTHQUAKES (V AND ABOVE) OCCURRING WITHIN  
200 MILES OF RADFORD ARMY AMMUNITION PLANT

DATE	Time			LAT (NORTH)	LONG (WEST)	INTEN (MM)	MAGNITUDE	REF*	DISTANCE (MILES)
	H	M	G						
2 FEB 1855	8	0	0.0	37.0	78.6	V		EQH	108
23 DEC 1875	4	45	0.0	37.6	78.5	VII		EQH	115
13 DEC 1879	7	0	0.0	35.2	80.8	V		EQH	137
6 AUG 1885	13	0	0.0	36.2	81.6	V		EQH	89
10 OCT 1885	4	35	0.0	37.7	78.8	VI		EQH	102
3 MAY 1897	17	18	0.0	37.1	80.7	VI		EQH	10
31 MAY 1897	18	58	0.0	37.3	80.7	VIII		EQH	11
22 OCT 1897	3	20	0.0	37.0	81.0	V		EQH	28
18 DEC 1897	23	45	0.0	37.7	77.5	V		EQH	171
5 FEB 1898	20	0	0.0	37.0	80.7	VI		EQH	15
13 FEB 1899	9	30	0.0	37.0	81.0	V		EQH	28
17 MAY 1901	7	0	0.0	39.3	82.5	V		EQH	180
5 MAR 1904	0	30	0.0	35.7	83.5	V		EQH	193
11 FEB 1907	13	22	0.0	37.7	78.4	VI		EQH	123
23 AUG 1908	9	30	0.0	37.5	77.9	V		EQH	147
8 MAY 1910	21	10	0.0	37.7	78.4	V		EQH	123
1 JAN 1913	18	28	0.0	34.7	81.7	VII		EQH	183
28 MAR 1913	21	50	0.0	36.2	83.7	VII		EQH	188
29 OCT 1915	6	0	0.0	35.8	82.7	V		EQH	153
21 FEB 1916	22	39	0.0	35.5	82.5	VI		EQH	159
26 AUG 1916	19	36	0.0	36.0	81.0	V		EQH	85
10 APR 1918	2	9	0.0	38.7	78.4	VI		EQH	156
6 SEP 1919	2	46	0.0	37.8	78.2	VI		EQH	169
7 AUG 1921	6	30	0.0	37.8	78.4	V		EQH	125
20 OCT 1924	8	30	0.0	35.0	82.6	V		EQH	189
6 DEC 1924	4	30	0.0	37.3	79.9	V		EQH	36
8 JUL 1926	9	50	0.0	35.9	82.1	VI		EQH	123
5 NOV 1926	15	53	0.0	39.1	82.1	VII		EQH	157
10 JUN 1927	7	16	0.0	38.0	79.0	V		EQH	101
30 OCT 1928	11	45	0.0	37.5	77.5			USE	168
3 NOV 1928	4	3	0.0	36.0	82.6	VI		CGS	140
27 DEC 1929	2	56	0.0	38.1	78.5	VI		USE	128
15 SEP 1930	7	40	0.0	37.5	77.5			USE	168
26 JUL 1945	10	32	15.0	34.5	81.5		5.6 PAS	G-R	192
20 JUN 1952	9	38	5.0	39.7	82.2	VI		ISS	195

TABLE 2.3-35 (Continued)

DATE	Time			LAT (NORTH)	LONG (WEST)	INTEN (MM)	MAGNITUDE	REF*	DISTANCE (MILES)
	H	M	G						
20 JUN 1952	9	38	6.0	39.7	82.2	VI		USW	199
23 OCT 1958	2	29	47.0	37.5	82.5			CGS	110
23 APR 1959	20	48	41.0	37.5	80.5	VI		USE	21
28 OCT 1963	22	38	35.0	36.7	81.0	V		CHC	41
25 NOV 1964	2	50	5.0	37.4	81.5		4.5	CGS	54
26 APR 1965	15	26	21.5	37.3	81.6			CGS	58
31 MAY 1966	6	19	2.1	37.6	78.0	V	3.1	CGS	142
8 APR 1967	5	40	32.3	39.6	82.5	V	4.5	CGS	194
16 DEC 1967	12	23	37.4	37.4	81.6		3.5	CGS	60
8 MAR 1968	5	38	15.1	37.0	80.5	IV	3.9	USE	12
8 MAR 1968	5	38	15.2	37.3	80.8	IV	3.9	RLA	17
20 NOV 1969	1	0	9.0	37.4	81.0	VI	4.8CGS	USE	29
11 DEC 1969	23	44	39.2	37.8	77.4	V		USE	177
13 DEC 1969	10	19	34.3	35.1	83.0	V		USE	198
30 JUL 1970	8	48	51.5	37.0	82.2		3.8	CGS	94
30 JUL 1970	15	15	16.3	37.0	82.2		4.0	CGS	94
11 AUG 1970	6	14	25.5	38.4	82.3	IV		USE	127
10 SEP 1970	1	41	10.0	36.1	81.4	V		USE	88
19 FEB 1971	23	11	41.7	37.1	83.2			NOS	149
1 APR 1971	5	5	11.0	37.4	81.6			NOS	61
12 SEPT 1971	0	6	27.1	38.1	77.4	V		ERL	180
9 OCT 1971	16	43	33.8	35.9	83.5	V	3.4	ERL	186
9 JAN 1972	23	24	29.1	37.4	81.6			ERL	59
20 MAY 1972	19	39	6.4	37.0	82.2			ERL	94
23 MAR 1974	9	46	38.0	38.9	77.8		2.5BLA	GS	192
30 MAY 1974	21	28	37.2	37.4	80.4		3.6BLA	GS	15
20 OCT 1974	15	13	55.1	39.1	81.6	V	3.4SLM	GS	143

## \* REFERENCES:

- EQH Earthquake History of the United States  
 USE Yearly publication 'United States Earthquakes'  
 CGS Coast and Geodetic Survey  
 G-R 'Seismicity of the Earth' by Gutenberg and Richter  
 ISS International Seismological Summary  
 CHC Chapel Hill, NC  
 BLA Blacksburg, VA  
 NOS National Ocean Survey  
 ERL Environmental Research Laboratory  
 GS Geological Survey

MODIFIED MERCALLI INTENSITY (DAMAGE) SCALE  
(Abridged)

- I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale.)
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale.)
- III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale.)
- IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)
- V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)
- VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale.)
- VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale.)
- VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX-Rossi-Forel Scale.)
- IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale.)
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale.)
- XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
- XII. Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown upward into the air.

site experience accelerations in excess of the Operating Basis Earthquake, shutdown would be mandatory until it could be demonstrated that no functional damage had occurred to those features of the plant necessary to assure plant safety.

A tentative value of .15g (one-half the maximum SSE) would be required to satisfy NRC criteria. Further studies should be performed to verify values for both the SSE and OBE.

2.3.4.8 Foundation Engineering. Three borings were drilled at the proposed site in a plan view of an equalateral triangle. Rock (red shale with calcareous and sandy zones) was encountered at approximately twenty feet below existing grade in each boring. A generalized subsurface profile is presented in subsection 2.2.5.2(2).

The borings were performed under the supervision of the Corps of Engineers, Norfolk District. The soil samples were classified according to the United Soil Classification System and the inspector's visual interpretation of material proportions. All soils were classified ML; inorganic silts and very fine sands with slight plasticity. No samples were tested in the lab to determine their strengths or other physical properties.

Generally, the strength of rock underlying the site should be suitable with minimal settlements and adequate bearing capacity.

### 2.3.5 Terrestrial and Aquatic Ecology

2.3.5.1 Terrestrial Ecology. The site is located in the Ridge and Valley section of the Oak-Chestnut Forrest Region (Ref. 2.0-34). This area is characterized by broad valleys from which rise rather level-crested longitudinal ridges. The ridges are most frequently of sandstone whereas the valley floors are underlain with limestone. These geological variations produce different habitats and consequently different vegetative

patterns. Secondary vegetation of ridges is usually dominated by oak. While oak is usually dominant in mesic slope forest, drier slopes are dominated by Chestnut oak, and pines are common on cliffs. Although most of the valleys are under cultivation, the forest type is dominated by white oak. Other accompanying species include tuliptree, hickories, and a number of oaks. Forests along slopes of streams are unlike those of mountain slopes. Beech is universally present with basswood, sugar maple, tuliptree, oaks, ash, and walnut frequently present.

The major tree species of the two county areas in which the Radford Army Ammunition Plants is located are the red oak, dogwood, hickory, maple and white oak in the valleys, and red oak, maple, white oak, and black gum on ridges and exposed slopes (Ref. 2.0-23).

Radford Army Ammunition Plant has 2,537 wooded acres out of a total area of 7,095 acres.

Aerial photographs of the immediate vicinity of the proposed power plant indicate that the area is forested by a mixture of evergreen and hardwood trees. The species composition is unknown. The site area slopes steeply downward on three sides toward Stroubles Creek and its tributaries. The slopes are also wooded. Access from the proposed plant site to the New River would include flat non-wooded habitat.

A list of frogs and toads of Virginia (Ref. 2.0-35) and snakes of Virginia (Ref. 2.0-36,37) have been published along with distribution maps. These articles have been used in compiling Tables 2.3-36 and 2.3-37 giving those animals which occur in either Pulaski or Montgomery Counties. The lack of still water on site will limit the breeding activities of amphibians to small still pools along streams. Gray tree frogs, wood frogs and green frogs are most likely inhabitants of the woodland slopes. The

woodland slopes of the site could provide habitat for most of the snakes listed in Table 2.3-37. The water snake and green snake could occur along streams such as Stroubles Creek.

Over 270 species of birds have been recorded in Montgomery County from 1891 through 1974 (Ref. 2.0-38), of which about 80 are considered rare. Murray speculates that such a large number of species is the result of the county being at median latitudes, the boundary of two drainage systems, and along a migration pathway. Table 2.3-38, modified from Murray (Ref. 2.0-38) lists those birds whose preferred habitat is present on site. Eliminating those species which have been recorded less than three times in the area, we are left with 236 avian species which are potential inhabitants of the site. These, of course, vary seasonally as indicated in Table 2.3-38.

No information concerning surveys of mammalian species in the vicinity of the site have been located, however, the present geographic ranges of 60 species include the Radford Army Ammunition Plant (Ref. 2.0-39). These species along with their preferred habitat are listed in Table 2.3-39.

For the purposes of this study those animals and plants which are rare or endangered, of commercial or recreational importance, or have shown declining populations in the area, are considered important. In addition, those organisms contributing significantly to the well being of the above species are also considered important.

No species of plants listed as rare or endangered have been reported at the Radford Army Ammunition Plant (Ref. 2.0-23). However, no comprehensive list of plants found has been compiled. Those rare and endangered species which might be expected to occur at the site because of their ranges and habitat preference are given in Table 2.3-40. The list is conservative and does not imply that all species are present.

Many of the tree species listed (Ref. 2.0-23) as present on site are valuable commercial species, including tulip tree, basswood, sugar maple, oak, black walnut, pine, ash and cherry. Pine, tulip tree and black walnut are the three most valuable timber trees on the Radford Army Ammunition Plant Complex (Ref. 2.0-23).

Several of the bird species which are likely to occur within the region of the Radford Army Ammunition Plant are considered rare or endangered (Table 2.3-41). Others have been placed on the Blue List which is published once a year under the auspices of the National Audubon Society. The list is a compilation of birds, which in the opinion of prominent ornithologists throughout the United States, have shown a serious decline in numbers. The rare and endangered Bald Eagle and Peregrine Falcon have also been recorded in Montgomery County. Both are presently considered rare. Since 1940, only one Bald Eagle has been sighted. Peregrine Falcons, while never common, formerly nested on cliffs along the New River (Ref. 2.0-38). Both of these species might be expected to use the present site for brief periods, but the nearness to human activities probably precludes their nesting on site.

Several of the species noted on the Blue List have also experienced a population decline in Montgomery County including: Marsh Hawk; Upland Sandpiper; Red-headed Woodpecker; Cliff Swallow; Bewick's Wren; and Grasshopper Sparrow (Table 2.3-41). These species should be given special consideration should they be found to be using the site intensively.

Two rare or endangered mammal species could presently use the site. These are both bats - the Indiana myotis and a subspecies of the Western big-eared bat, the Virginia big-eared bat. Both species inhabit caves, with the Indiana myotis primarily confined to several large caves in

Kentucky (Ref. 2.0-54). The Virginia big-eared bat inhabits small caves (Ref. 2.0-54). No caves are presently known to exist at the site, but one should be alert to their presence and possible importance.

Many of the bird and mammal species likely to occur on site are considered game animals by the State of Virginia (Table 2.3-39) (Ref. 2.0-65). The birds include: geese; ducks; Ruffed Grouse; Bobwhite; Ring-Necked Pheasant; Turkey; Common Gallinule; American Coot; American Woodcock; Common Snipe; and Mourning Dove. Game mammals include: black bear, red fox, gray fox, bobcat, squirrels, rabbits, and Virginia deer. Life history information for rare and endangered species and game species are included in Tables 2.3-39 and 2.3-42. Probable food chains of the important species are depicted in Figure 2-5.

The biological communities have been and still are under stress from the activities of man. The area was altered by clearing, cultivation and grazing prior to its acquisition and development as a manufacturing area. Heavy lumbering of the woodlands occurred prior to government acquisition.

Presently, the woodlands are under a forest management program, since 1955, with lumbering on a seven year cycle. Mature trees are lumbered and low value or dead trees selectively removed. Herbicides are used in the control of unwanted species (Ref. 2.0-23).

The manufacturing facility was constructed on cleared agricultural lands. However, this land has either been covered with buildings or manipulated so that succession and forest development has been arrested. Portions of the non-forested land is presently being used for burial of solid wastes or burning areas, with most of the remainder kept mowed.

Noise, man's activities, and emissions associated with the manufacturing probably affect terrestrial biological communities. Emission effects on trees downwind of the plant are evident (Ref. 2.0-23).

There have been buildups of both deer and red fox populations within the RAAP property, probably because of good habitat, lack of predators, and no hunting. A fence surrounding the plant complex also inhibits natural dispersion of the population. Additional food in the form of grain stocked shelters are provided for deer. Excess deer are trapped by the Virginia Department of Conservation (Ref. 2.0-23) for stocking elsewhere. Red foxes have been trapped in the past by the Virginia Commission of Game and Inland Fisheries when their dense populations posed threat of rabies. The last trapping was in 1966 (Ref. 2.0-23).

2.3.5.2 Aquatic Ecology. The New River, approximately 150 yards wide flows through RAAP for nearly three miles. The river is rapid with both riffle and pool habitats. The substrate is highly variable with areas of bedrock, boulders, gravel, sand and mud (Ref. 2.0-12). A small stream, Stroubles Creek, which drains most of the Southeastern half of RAAP flows into the New River. These waters, because of the shale, sandstone and limestone over which they flow, are hard with concentration of  $\text{CaCO}_3$  ranging from 50 to 199 ppm in the New River below RAAP (Ref. 2.0-23).

Approximately 15 miles upstream of the site is Claytor Lake. The regulation of discharge from the lake produces diurnal changes in elevation of the river at RAAP which can vary as much as 4 feet (Ref. 2.0-12). From the town of Radford 11 river miles upstream of RAAP the New River receives 2.5 million gallons of primary sewage per day. However, because of the river's high reaeration characteristics and high base flow it is considered clean (Ref. 2.0-23). Algal indicator species composition on the other hand

indicate a possible nutrient enrichment of the New River prior to entering RAAP (Ref. 2.0-12). Nutrient enrichment of the river as it passed through the Ammunition Plant was very evident from measurements of nitrate and phosphate in 1971. Nitrate levels were 1.69 PPM as the river entered RAAP and 13.90 PPM near the river's bend after passing many of the RAAP outfalls. Phosphate levels were 0.135 PPM and 0.41 PPM at the same location (Ref. 2.0-12). Stroubles creek is somewhat degraded at the point that it enters RAAP from sewage disposal by the town of Blacksburg (Ref. 2.0-23).

Both the New River and Stroubles Creek serve as waste disposal receiving bodies for RAAP. The biological studies on the inhabitants of these waters have been largely designed to document and define the effects of the discharges. Two studies, one in June 1971 (Ref. 2.0-12) and one in October 1972 (Ref. 2.0-23) were undertaken with these goals in mind. Both attempted to sample in physically similar environments (riffles) at locations above and below various outfalls. The first study sampled benthos, algae, aquatic macrophytic vegetation and fish while the latter surveyed only benthos and algae. The 1971 algal study of the New River found little differences between stations as far as species composition except for a trend toward a greater dominance by green algae as one progressed downstream. Reductions in taxa of algae were noted both immediately below the thermal and ash discharge from the power plant (Power House #2) and below the burning grounds. A list of algal species collected is presented in the Wodehouse, et al. (1973) study (Ref. 2.0-12). The 1972, Department of the Army, study only looked at the diversity of diatom species. Two stations upstream from any discharge points were used to establish baseline conditions. Downstream of the Oleum Plant wastes, a slight depression in the diversity index was noted. Further downstream below the discharge of

thermal and chemical waste from the Waste Acid Neutralization Facility a large depression was noted on the right side of the river. Below the mouth of Stroubles Creek an even greater depression of the diversity index was noted on the right side of the river and a suggestion of a decrease was present from the left side of the river. Station further downstream showed a recovery toward baseline conditions as outlined occurred.

Stroubles Creek was sampled in the 1972 Department of the Army study (Ref. 2.0-23). The first five stations were above any discharge points from the RAAP facility. The diversity indices calculated from the diatom collections at these stations were relatively high and constant, except below an area of road construction. Below the thermal and chemical waste outfall of the TNT area a large depression of the diversity index was seen. Additional wastes from the TNT area enter further downstream and produce even greater deterioration.

Sixty-eight species of flowering plants, one aquatic moss and one macroscopic algae were collected below the high water mark along the New River. A species list is given in the report by Mitchell (1973). The variety of plant species varied widely from station to station with lowest numbers present below the Oleum plant and the power plant outfalls. Most sensitive genera were Potomogeton, Chara, and Stellaria with Elodea and Frontinalis apparently somewhat less sensitive (Ref. 2.0-12).

Biomass studies of the species Podostemum ceratophyllum were conducted at intervals along the river. Biomass dropped in the region of the outfalls and then surged to new highs somewhat below the outfalls. This pattern suggest toxicity in the area of depression, and following dilution of the toxicant, increase productivity due to increased nutrients (Ref. 2.0-12).

The 1971 study (Ref. 2.0-12) found few differences in the benthic fauna (either species or density) upstream or downstream of the RAAP waste outfalls. Few species were collected at any station which the authors (Holliman and Parsons, 1973) attribute to the relative large amount of bedrock and the season (early summer). A list of species collected is presented by Holliman and Parson, Ref. 2.0-12. Species intolerant to pollution were present at all stations.

The 1972 Department of the Army Study, however, did indicate a degradation of benthic invertebrate communities below the RAAP outfalls, especially the oleum plant, the power plant and general sewer and at the mouth of Stroubles Creek. Sensitive genera, Hydropsyche, Stenonema, Isonychia and Macronemum were present in the river as it enters and leaves RAAP, but not in the region of the outfalls. A list of species is given in this report. Some of the differences in the two studies may be related to the seasonal differences in sampling (one in early summer; one in fall).

Both studies found indications of pollution in Stroubles Creek, both as it entered RAAP and further downstream below outfalls of the TNT plant (Ref. 2.0-12). The creek was found to be nearly abiotic near its mouth (Ref. 2.0-12).

The New River both above and below RAAP supports about 30 species of fish (Table 2.3-44, Ref. 2.0-12). Below the oleum outfall only 5 species were collected. Further downstream but above the power plant 15 species were collected in low numbers. Those species which were absent in the stressed zone were the hog sucker, many species of minnows, fantail darter, yellow perch, and bass.

Only two specimens were taken in Stroubles Creek, both blacknose dace, which were speculated to have come from the New River (Ref. 2.0-12). This

creek was reported to have supported about 20 species in 1951 and 1952. By 1954 only seven species were found (Ref. 2.0-12).

Of the 31 species of fish reported to occur at RAAP, none are reported to be rare or endangered. Seven of the 31 species are considered game species in the State of Virginia (Table 2.3-43). The walleye, while not collected, is also an important game species of the New River.

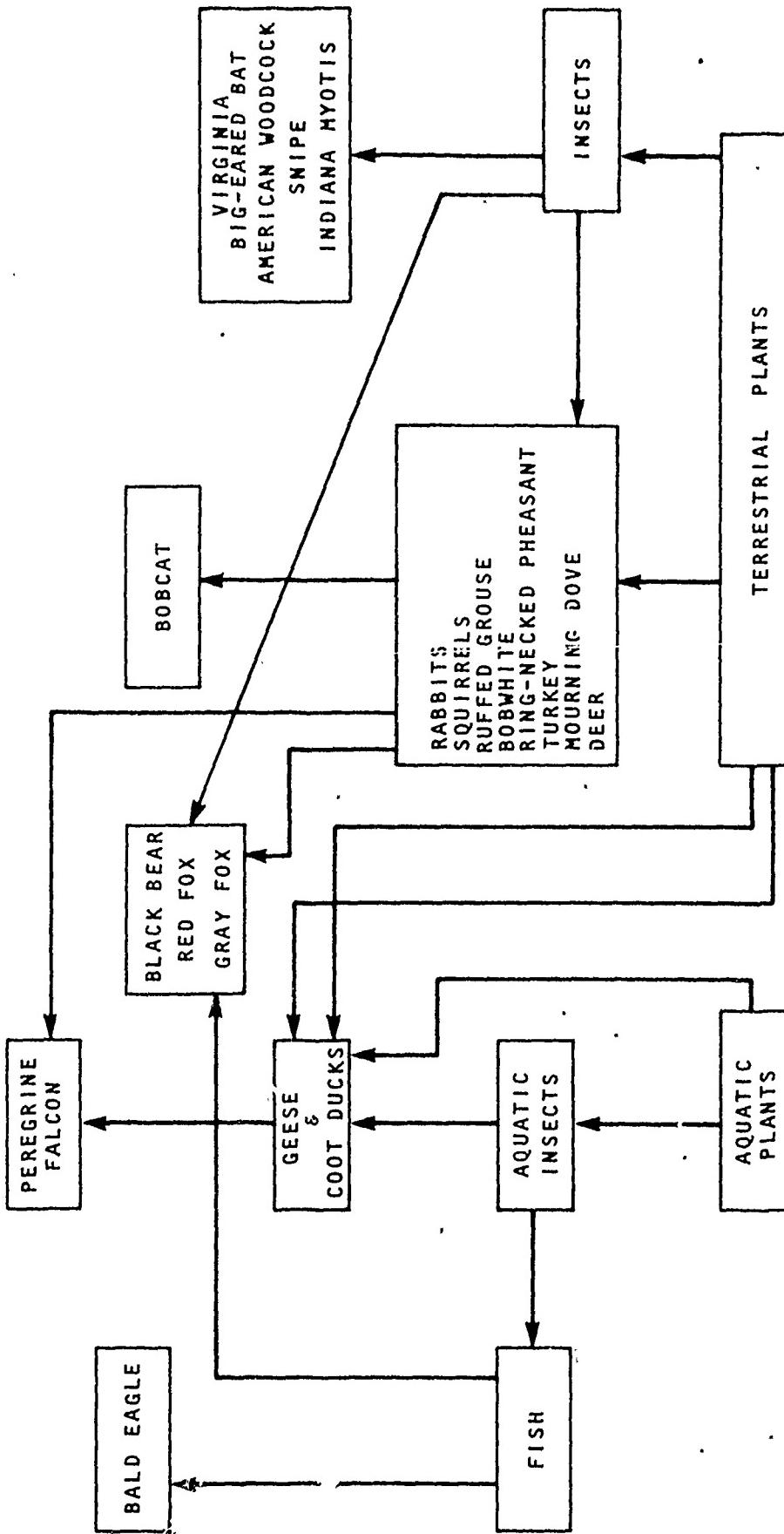
Habitat requirements of those fish species listed as important are given in Table 2.3-44. Life history characteristics are summarized in Table 2.3-43. All game species are carnivorous and therefore occupy a place at the top of the food chain. When young they feed largely on zooplankton, as juveniles they feed on benthic invertebrates, and as adults they feed on a combination of invertebrates and other fish. They are therefore dependant on all categories of biota for their survival.

It appears that both the New River and Stroubles Creek are presently under considerable stress in the area under consideration. Both receive sanitary wastes prior to entering RAAP and the depth of the New River is regulated by a dam. Within the Arsenal itself, the waters are further degraded by the addition of acids, nutrients, heat, ash, sediment, domestic and industrial wastes. The effects of these are mirrored in the kind, number, and species distribution of the organisms at various locations within the arsenal. The New River, because of its higher base flow and recreation characteristics is able to assimilate the present pollutants with few noticeable effects on the biota of the river as it leaves the site. Stroubles Creek on the other hand is smaller and is almost abiotic near its mouth.

TABLE 2.3-36: FROGS AND TOADS OF POLASKI AND MONTGOMERY COUNTIES, VA.\*

Eastern spadefoot	<u>Scaphiopus holbrookii</u>
American toad	<u>Bufo americanus</u>
Fowler's toad	<u>B. woodhousei fowleri</u>
Spring peeper	<u>Hyla crucifer</u>
Gray treefrog	<u>H. versicolor</u>
Upland chorus frog	<u>Pseudacris triseriata feriarum</u>
Mountain chorus frog	<u>P. brachyphona</u>
Bullfrog	<u>Rana catesbeiana</u>
Green frog	<u>R. clamitans melanota</u>
Northern leopard frog	<u>R. pipiens pipiens</u>
Pickerel frog	<u>R. polustris</u>
Wood frog	<u>R. sylvatica</u>

\*Mitchell, 1975



PROBABLE FOOD CHAIN OF IMPORTANT SPECIES  
POTENTIALLY OCCURRING ON THE SITE

FIGURE 2-5

TABLE 2.3-37: SNAKES OF PULASKI AND MONTGOMERY COUNTIES, VIRGINIA\*

Northern water snake	<u>Natrix sipedon sipedon</u>
Queen snake	<u>N. septemvittata</u>
Northern brown snake	<u>Storeria dekayi dekayi</u>
Red-bellied snake	<u>S. occipitomaculata</u>
Eastern garter snake	<u>Thamnophis sirtalis sirtalis</u>
Eastern ribbon snake	<u>T. sauritus sauritus</u>
Eastern hognose snake	<u>Heterodon platyrhinos</u>
Northern ringneck snake	<u>Diadophis punctatus edwardsi</u>
Eastern worm snake	<u>Carpophis amoenus amoenus</u>
Northern black racer	<u>Crotuber constrictor constrictor</u>
Rough green snake	<u>Opheodrys aestivus</u>
Corn snake	<u>Elaphe guttata guttata</u>
Black rat snake	<u>E. obsoleta obsoleta</u>
Northern pine snake	<u>Pituophis melanoleucus melanoleucus</u>
Eastern milk snake	<u>Lampropeltis doliata triangulum</u>
Mole snake	<u>L. calligaster rhombomaculata</u>
Northern copperhead	<u>Agkistrodon contortrix mokeson</u>
Timber rattlesnake	<u>Crotalus horridus horridus</u>

\*Mitchell, 1974 A and B.

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE

SPECIES (1)	STATUS (1)	SEASONAL OCCURRENCE (1)	PREFERRED HABITAT (2)	SPECIAL STATUS
Declined in County Since 1900 <sup>(1)</sup>				*
Game Species <sup>(5)</sup>				* * * * *
Blue List <sup>(4)</sup>	*	*	*	
Rare or Endangered <sup>(3)</sup>				
Cliffs				
Fields & Pastures		*	*	
Woodlands				*
Stream Sides		* * *	* * * *	* * * *
Open Water	* * *		* * * *	* * *
Summer Visitor		* * * *		*
Winter Visitor	*	*		* * * * *
Transient	*	*	*	*
Winter Resident				
Summer Resident		*	*	
Permanent Resident		*		
Common Loon	U			
Horned Grebe	U			
Pied-billed Grebe	C,U			
Double-crested Cormorant	R			
Great Blue Heron	U			
Green Heron	C			
Little Blue Heron	R			
Cattle Egret	R			
Great Egret	U			
Black-crowned Night Heron	U			
Yellow-crowned Night Heron	U			
Least Bittern	U			
American Bittern	R			
Whistling Swan	U			
Canada Goose	C			
Mallard	C,R			
Black Duck	U			
Gadwall	U			
Pintail	U			
Green-winged Teal	U			
Blue-winged Teal	C,R			
American Widgeon	C,R			
Northern Shoveler	U			
Wood Duck	C,U			

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	STATUS (1)	SEASONAL OCCURRENCE (1)	PREFERRED HABITAT (2)	SPeCIAL STATUS
Declined in County Since 1900 (1)				*
Game Species (5)		*	*	*
Blue List (4)		*		*
Rare or Endangered (3)				
Cliffs				
Fields & Pastures				*
Woodlands				*
Stream Sides				*
Open Water		*	*	*
Summer Visitor		*		
Winter Visitor		*	*	*
Transient	*	*	*	
Winter Resident				
Summer Resident				*
Permanent Resident			*	*
Redhead	U			
Ring-necked Duck	C,U			
Canvasback	U			
Great Scaup	U			
Lesser Scaup	C,R			
Common Goldeneye	C			
Bufflehead	C			
Oldsquaw	R			
White-winged Scoter	R			
Ruddy Duck	U,R			
Hooded Merganser	FC			
Common Merganser	R			
Red-breasted Merganser	U,R			
Turkey Vulture	C	*		
Black Vulture	C	*		
Gashawk	R	*		
Sharp-shinned Hawk	U	*		
Cooper's Hawk	U	*		
Red-tailed Hawk	FC	*		
Red-shouldered Hawk	U	*		
Broad-winged Hawk	U	*		
Rough-legged Hawk	R	*		
Golden Eagle	R	*		

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	Status (1)	Seasonal Occurrence (1)	Preferred Habitat (2)	Special Status	
				(3)	(4)
Declined in County Since 1900 (1)	**	*	*	*	*
Game Species (5)		*****		**	
Blue List (4)	**	**			*
Rare or Endangered (3)	*	*			
Cliffs	*	*			
Fields & Pastures	*	***	**	**	*
Woodlands	*	*	*	*	
Stream Sides	*	*	*	*	***
Open Water	*	**	**		
Summer Visitor					
Winter Visitor		**			
Transient	**	*			
Winter Resident	*				
Summer Resident					*
Permanent Resident	*				
Bald Eagle	R				
Marsh Hawk	U				
Osprey	U,R				
Peregrine Falcon	R				
Merlin	R				
American Kestrel	FC				
Ruffed Grouse	FC				
Bobwhite	C				
Ring-necked Pheasant	U				
Turkey	R				
Common Gallinule	C,U				
American Coot	U				
Semipalmated Plover	C				
Killdeer	C				
American Golden Plover	R				
Black-bellied Plover	R				
American Woodcock	U				
Common Snipe	C				
Upland Sandpiper	R				
Spotted Sandpiper	C				
Solitary Sandpiper	C				
Greater Yellowlegs	U				
Lesser Yellowlegs	C				

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	STATUS (1)	SEASONAL OCCURRENCE (1)	PREFERRED HABITAT (2)	SPeCIAL STATUS
Declined in County Since 1900 (1)		*		* * *
Game Species (5)				*
Blue List (4)				* *
Rare or Endangered (3)				
Cliffs				
Fields & Pastures				* *
Woodlands				* * * * *
Stream Sides		* * * * *		
Open Water			* * * * *	
Summer Visitor				*
Winter Visitor				*
Transient		* * * * *		
Winter Resident				
Summer Resident				* *
Permanent Resident				* * * * *
Pectoral Sandpiper	U			
White-rumped Sandpiper	R			
Least Sandpiper	FC			
Semipalmated Sandpiper	U			
Western Sandpiper	R			
Short-billed Dowitcher	R			
Herring Gull	R		I,R	
Ring-billed Gull			U,R	
Bonaparte's Gull			R	
Forster's Tern	U			
Common Tern	U			
Black Tern	U	C		
Rock Dove	C	C		
Mourning Dove	C	C		
Yellow-billed Cuckoo	C	D		
Black-billed Cuckoo	D	D		
Barn Owl	U	U	FC	
Screech Owl			U	
Great Horned Owl			U	
Barred Owl			U	
Long-eared Owl			R	
Saw-whet Owl			R	
Whip-poor-will			U	

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	Status (1)	Seasonal Occurrence (1)	Preferred Habitat (2)	Special Status
Common Nighthawk	C			
Chimney Swift	C			
Ruby-throated Hummingbird	C			
Belted Kingfisher	C			
Common Flicker	C			
Pileated Woodpecker	EC			
Red-bellied Woodpecker	FC			
Red-headed Woodpecker	U			
Yellow-bellied Sapsucker	FC			
Hairy Woodpecker	FC			
Downy Woodpecker	C			
Eastern Kingbird	FC			
Great Crested Flycatcher	FC			
Eastern Phoebe	C,U			
Yellow-bellied Flycatcher	R			
Acadian Flycatcher	C			
Least Flycatcher	R,U			
Eastern Wood Pewee	C			
Olive-sided Flycatcher	R			
Horned Lark	U,FC			
Tree Swallow	U			
Bank Swallow	R			
Rough-winged Swallow	FC			
Declined in County Since 1900 (1)		*	*	*
Game Species (5)				
Blue List (4)	*		*	
Rare or Endangered (3)				
Cliffs				*
Fields & Pastures	***			***
Woodlands	*****			*****
Stream Sides	*****			*****
Open Water	*			*
Summer Visitor	*			
Winter Visitor				
Transient	*			
Winter Resident			*	
Summer Resident	**			**
Permanent Resident				

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	STATUS (1)	SEASONAL OCCURRENCE (1)	PREFERRED HABITAT (2)	SPeCIAL STATUS
Declined in County Since 1900 <sup>(1)</sup>		*		*
Game Species <sup>(5)</sup>				*
Blue List <sup>(4)</sup>		**		*
Rare or Endangered <sup>(3)</sup>				
Cliffs		*		
Fields & Pastures	***	**	*	*
Woodlands		***	***	***
Stream Sides			*	
Open Water	*	*		
Summer Visitor				
Winter Visitor		**	***	**
Transient	*			*
Winter Resident				*
Summer Resident	*	*	*	***
Permanent Resident	***	***	***	
Barn Swallow	C	R		
Cliff Swallow	U	FC		
Purple Martin				
Blue Jay	C	R		
Common Raven	C	FC		
Common Crow	C	FC		
Fish Crow				
Black-capped Chickadee	C	C		
Carolina Chickadee		FC		
Tufted Titmouse	C	FC		
White-breasted Nuthatch	C	FC		
Red-breasted Nuthatch	C	FC		
Brown Creeper				
House Wren	C,R	FC		
Winter-Wren	R			
Berwick's Wren	C			
Carolina Wren	C	R		
Short-billed Marsh Wren	R			
Mockingbird	C,R			
Gray Catbird	C,UC			
Brown Thrasher	C,UC			
American Robin	C			
Wood Thrush	U			
Hermit Thrush				

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	STATUS (1)	SEASONAL OCCURRENCE (1)	PREFERRED HABITAT (2)	SPECIAL STATUS
Declined in County Since 1900 <sup>(1)</sup>		*		*
Game Species <sup>(5)</sup>				
Blue List <sup>(4)</sup>			*	
Rare or Endangered <sup>(3)</sup>				
Cliffs				
Fields & Pastures		*	* * *	
Woodlands		* * *	* * * * *	* * * * *
Stream Sides				*
Open Water				*
Summer Visitor				
Winter Visitor	*	* * *		
Transient	* * *	*		* * * *
Winter Resident				
Summer Resident		*	* * * *	* * *
Permanent Resident		*	* * *	
Swainson's Thrush	C,R			
Gray-checked Thrush	U			
Veery	U			
Eastern Bluebird	U			
Blue-gray Gnatcatcher	C			
Golden-crowned Kinglet	C			
Ruby-crowned Kinglet	C,U			
Water Pipit	U			
Cedar Waxwing	FC			
Loggerhead Shrike	U			
Starling	C			
White-eyed Vireo	FC			
Yellow-throated Vireo	FC			
Solitary Vireo	U,FC			
Red-eyed Vireo	C			
Philadelphia Vireo	R			
Warbling Vireo	U			
Black-and-white Warbler	C			
Prothonotary Warbler	R			
Worm-eating Warbler	C			
Golden-winged Warbler	U			
Blue-winged Warbler	R,U			
Brewster's Warbler	R			

TABLE 2: 3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	Status (1)	Preferred Habitat (2)	Special Status	Seasonal Occurrence (1)	
				Summer Visitor	Winter Visitor
Tennessee Warbler	C			R	*
Orange-crowned Warbler	R				
Nashville Warbler	U,R				
Northern Parula	C				
Yellow Warbler	C				
Magnolia Warbler	C				
Cape May Warbler	C				
Black-throated Blue Warbler	R,C				
Yellow-rumped Warbler	C,U				
Black-throated Green Warbler	U,C				
Cerulean Warbler	U				
Blackburnian Warbler	U,C				
Yellow-throated Warbler	R				
Chestnut-sided Warbler	U,C				
Bay-breasted Warbler	U				
Brackpoll Warbler	C				
Pine Warbler	C				
Prairie Warbler	C				
Western Palm Warbler	R				
Yellow Palm Warbler	C				
Overbird	C				
Northern Waterthrush	D				
Louisiana Waterthrush	C				
Kentucky Warbler	D				

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	Status (1)	Seasonal Occurrence (1)	Preferred Habitat (2)	Special Status
Declined in County Since 1900 (1)			*	
Game Species (5)				
Blue List (4)		*		
Rare or Endangered (3)				
Cliffs				
Fields & Pastures		*	*****	*** * * *
Woodlands	**	****	*	* * * * *
Stream Sides		*		
Open Water				
Summer Visitor				
Winter Visitor			*	**
Transient	**	***	*	* * *
Winter Resident		***		*
Summer Resident		*	***	*** * ***
Permanent Resident		*	*	*
Connecticut Warbler	R	R		
Mourning Warbler	C	C		
Common Yellowthroat	C	C		
Yellow-breasted Chat	C	C		
Hooded Warbler	U	U		
Wilson's Warbler	U	U		
Canada Warbler	U,C	U,C		
American Redstart	U,C	U,C		
House Sparrow	U	U		
Bibolink	C	C		
Eastern Meadowlark	C	C		
Red-winged Blackbird	C	C		
Orchard Oriole	D	D		
Northern (Baltimore) Oriole	C,R	C,R		
Rusty Blackbird	C,FC	C,FC		
Brewer's Blackbird	R	R		
Common Grackle	C,Irr	C,Irr		
Brown-headed Cowbird	C	C		
Scarlet Tanager	C	C		
Summer Tanager	D	D		
Cardinal	C	C		
Rose-breasted Grosbeak	R,U	R,U		
Blue Grosbeak	U	U		
Indigo Bunting	C	C		

TABLE 2.3-38: AVIAN SPECIES POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	STATUS (1)	SEASONAL OCCURRENCE (1)	PREFERRED HABITAT (2)	SPECIAL STATUS
Rick's Siskin	R	Irr		
Evening Grosbeak	FC			
Purple Finch	R,U			
House Finch	Irr			
Pine Siskin	C			
American Goldfinch	U	C,U		
Red Crossbill	R	FC,R		
White-winged Crossbill	C			
Rufous-sided Towhee	U			
Savannah Sparrow	R			
Grasshopper Sparrow	R			
Henslow's Sparrow	R			
Vesper Sparrow	FC			
Bachman's Sparrow	R			
Dark-eyed Junco	C		*	
Tree Sparrow	U	C,R		
Chipping Sparrow	C,R			
Field Sparrow	C			
White-crowned Sparrow	C			
White-throated Sparrow	C			
Fox Sparrow	U			
Lincoln's Sparrow	U			
Swamp Sparrow	U			
Song Sparrow	C			
Declined in County Since 1900 (1)			*	*
Game Species (5)				*
Blue List (4)			***	*
Rare or Endangered (3)				*
Cliffs				
Fields & Pastures	*	***	*****	****
Woodlands	**	*	****	***
Stream Sides				***
Open Water				
Summer Visitor				
Winter Visitor		***	**	***
Transient	*		*	***
Winter Resident				
Summer Resident		*	*	
Permanent Resident			*	

TABLE 2.3-39: MAMMALS POTENTIALLY OCCURRING ON THE SITE

SPECIES (1)	PREFERRED HABITAT (1) (2)	SPECIAL STATUS	Game Species (4)
			Rare or Endangered (3)
Caves			
Fields & Pastures			
Woodlands			
Stream Sides			
Common Name	Scientific Name		
Opossum	<u>Didelphis virginiana</u>	*	*
Star-nosed mole	<u>Condylura cristata</u>	*	*
Eastern mole	<u>Scalopus aquaticus</u>	*	*
Hairy-tailed mole	<u>Parascalops breweri</u>	*	*
Masked shrew	<u>Sorex cinereus</u>	*	*
Smokey shrew	<u>S. fumeus</u>	*	*
Southern shrew	<u>S. longirostris</u>	*	*
Long-tailed shrew	<u>S. dispar</u>	*	*
Northern water shrew	<u>S. palustris</u>	*	*
Pigmy shrew	<u>Microsorex hoyi</u>	*	*
Least shrew	<u>Cryptotis parva</u>	*	*
Short-tailed shrew	<u>Blarina brevicauda</u>	*	*
Little brown myotis	<u>Myotis lucifugus</u>	*	*
Keen myotis	<u>M. keenii</u>	*	*
Indian myotis	<u>M. sodalis</u>	*	*
Small-footed myotis	<u>M. subulatus</u>	*	*
Silver-haired bat	<u>Lasiurus noctivagans</u>	*	*
Eastern pipistrelle	<u>Pipistrellus subflavus</u>	*	*
Big brown bat	<u>Eptesicus fuscus</u>	*	*
Red bat	<u>Lasionycteris borealis</u>	*	*
Hoary bat	<u>L. cinereus</u>	*	*
Evening bat	<u>Nycticeius humeralis</u>	*	*
Western big-eared bat	<u>Plecotus townsendii</u>	*	*
Eastern big-eared bat	<u>P. rafinesquii</u>	*	*

TABLE 2.3-39: MAMMALS POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	PREFERRED HABITAT (1) (2)	SPECIAL STATUS	SPECIES (1)			
			Caves	Fields & Pastures	Woodlands	Stream Sides
Black bear	<u><i>Ursus americanus</i></u>	*				
Raccoon	<u><i>Procyon lotor</i></u>		*	*		
Least weasel	<u><i>Mustela rixosa</i></u>		*	*		
Long-tailed weasel			*	*		
Rink	<u><i>M. frenata</i></u>		*	*		
River otter	<u><i>Lutra canadensis</i></u>		*	*		
Spotted skunk	<u><i>Spiilogale putoris</i></u>		*	*		
Stripped skunk	<u><i>Mephitis mephitis</i></u>		*	*		
Fox	<u><i>Vulpes fulva</i></u>		*	*		
Cray fox	<u><i>Urocyon cinereoargenteus</i></u>		*	*		
Bobcat	<u><i>Lynx rufus</i></u>		*	*		
Rodchuck	<u><i>Marmota monax</i></u>		*	*		
Eastern chipmunk	<u><i>Tamias striatus</i></u>		*	*		
Eastern gray squirrel	<u><i>Sciurus carolinensis</i></u>		*	*		
Eastern fox squirrel			*	*		
Red squirrel	<u><i>Tamiasciurus hudsonicus</i></u>		*	*		
Southern flying squirrel	<u><i>Glaucomys volans</i></u>		*	*		
Northern flying squirrel	<u><i>G. sabrinus</i></u>		*	*		
Eastern harvest mouse	<u><i>Reithrodontomys humulis</i></u>		*	*		
Leer mouse	<u><i>Peromyscus maniculatus</i></u>		*	*		
White-footed mouse	<u><i>P. leucopus</i></u>		*	*		
Golden mouse	<u><i>P. nuttalli</i></u>		*	*		
Eastern wood rat	<u><i>Neotoma floridana</i></u>		*	*		
Rice rat	<u><i>Oryzomys palustris</i></u>		*	*		
Southern bog lemming	<u><i>Synaptomys cooperi</i></u>		*	*		
Foreal red-backed vole	<u><i>Clethrionomys gapperi</i></u>		*	*		

TABLE 2.3-39: MAMMALS POTENTIALLY OCCURRING ON THE SITE (Continued)

SPECIES (1)	PREFERRED HABITAT (1) (2)	SPECIAL STATUS	
		Game Species (4)	Rare or Endangered (3)
Meadow vole	Caves	*	*
Yellownose vole	Fields & Pastures	*	*
Pine vole	Woodlands	*	*
Muskrat	Stream Sides	*	*
Meadow jumping mouse		*	*
Woodland jumping mouse		*	*
Snowshoe hare		*	*
Eastern cottontail		*	*
New England cottontail		*	*
Virginia deer		*	*
		* * * *	

(1) Burt and Grossenheimer, 1964

(2) Hamilton, 1943

(3) U.S. Dept. of Interior, 1973

(4) McInteer, 1974

TABLE 2-3-40: RARE OR ENDANGERED PLANTS \*POTENTIALLY OCCURRING AT THE SITE

SPECIES	Scientific Name (1)	Common Name (2, 3 or 4 unless noted)	HABITAT (2) (3) (4)			
			Fields	Stream Banks	Dry Lime-stone Hills	Dry Sandy Woodlands
<i>Anemone minima</i>	Anemone		*	*	*	*
<i>Asplenium ebenoides</i>	Scott's spleenwort <sup>5</sup>		*	*	*	*
<i>A. Kentuckiense</i>	Kentucky spleenwort <sup>5</sup>		*	*	*	*
<i>Buckleya distichophylla</i>	Buckleya		*	*	*	*
<i>Calamagrostis porteri</i>	Reed-bentgrass		*	*	*	*
<i>Carex biltmoreana</i>	Sedge		*	*	*	*
<i>C. chapmanii</i>	Sedge		*	*	*	*
<i>Clematis addisonii</i>	Leather flower		*	*	*	*
<i>Cimicifuga rubifolia</i>	Bugbane		*	*	*	*
<i>Cymophyllum fraseri</i>	Fraser's sedge		*	*	*	*
<i>Echinacea laevigata</i>	Purple coneflower		*	*	*	*
<i>Heuchera hispida</i>	Alumroot		*	*	*	*
<i>Hexastylis naniflora</i>	Heart leaf		*	*	*	*
<i>H. lewissii</i>	Heart leaf		*	*	*	*
<i>Isoetes virginica</i>	Quillwort		*	*	*	*
<i>Isotria medeoloides</i>	Little five-leaves		*	*	*	*
<i>Lilium grayi</i>	Lilly		*	*	*	*
<i>Nestronia umbellula</i>	Nestronia <sup>6</sup>		*	*	*	*
<i>Saxifraga careyana</i>	Saxifrage		*	*	*	*
<i>S. caroliniana</i>	Saxifrage		*	*	*	*
<i>Shortia galacfolia</i>	Oconee bells		*	*	*	*
<i>Synandra hispidula</i>	Synandra <sup>7</sup>		*	*	*	*

- (1) U.S. Dept. of Interior, 1975  
 (2) Ferhald, 1970  
 (3) Gleason, 1968  
 (4) Radford, et al., 1968

- (5) Cobb, W., 1963  
 (6) Petrides, W., 1972  
 (7) Wharton and Barbour, 1971

TABLE 2.3-41: SOME IMPORTANT SPECIES OF BIRDS LIKELY TO OCCUR AT RAAP - THEIR LIFE HISTORIES AND HABITAT REQUIREMENTS

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS			
		Age at loss of Parental Care (i.e. fledgling)	Reproductive Season(s)	Life Span	Population Fluctuation
Wood Duck	Open woodlands around lakes and streams. (1) Nests in cavities in trees. (2)	10-15 (2)	1 (2)	Inc = 28-30 days	Spring (1) March-early July (3)
Bald Eagle	Usually feeds on fish, roosts and nests in large living trees; tends to repeatedly use same nesting site. (4)	4 yrs. (5)	2 (5) (6)	Inc = 34-35 days (4)	Mid-Spring (4) July (3)
Peregrine Falcon	Breeding usually in vicinity of cliffs in mountains, or along deep gorges of larger streams. Commonly occurs along ocean beach, bay shores and tidal marshes. (3)	2-4 (5)	One clutch, but will lay 2nd or 3rd set if eggs taken (4)	Inc = 33 to 35 days (4)	Mid-Feb. to early June (3)
Ruffed Grouse	Young hardwoods with ample bushy understory. (7) Need brushy under-story for young open Woods o.k. for adults, like aspen. (8) Clearings in open woods. (1)	10-15 (6)	1 (9)	Inc = 24 days (7)	late spring (7) 9 yr. cycle (10)

TABLE 2.3-41 (Continued)

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS					
		Population Fluctuation	Age at loss of Parental Care (i.e. fledgling)	Reproductive Season(s)	Life Span	Brooding (Br) Incubation (Inc) Gestation (G)	Clutches/Litters per year
Bobwhite	In cx near hedge rows, wood margins, and brushy fields, in agricultural areas or on abandoned farmland. (3)	12-18 (15)	2 (14)	24 days (15)	Inc = Early May to late Sept. (3)		
Ring-necked Pheasant	In open woods, farmland, brush, tall hayfield veg., hedges & corn. (1) Cover reeeded for best productivity. (11) Needs calcium bearing grit for egg laying & growth of young. (6)	10 (12) 8-13 (13)	multiple (12)	Inc = May to late July 23-25 days (14)			
Turkey	Extensive tracts of forest. (3) Prefers open woodlands with abundance of mast producing trees. (16)	Females breed at 1 yr., Males at (15) 2 yr.	9-18 usually 9-12 (15)	Inc = 28 days (17)	5 years, rarely 9 years (16) (17)	April to July	
American Coot	Brackish estuaries and ponds in brackish marshes that contain plentiful aquatic plant growth. Also occurs on inland ponds and lakes. (3)	7-16 (15)	Inc = 21-22 days (18)		June (19) June (21)		
American Woodcock	Breeding: thickets or open stands of shrubs & small trees on or adjacent to damp or wet areas. Transient & wintering: various types of shrub & forest swamps. (3)	3-4 (19)	1-2 (19)	Inc = 20-21 days (19)	Up to 12 years (20)	Eng. dates March to mid-June (3) 1.5 to 6 territorial m/100 a (3)	

TABLE 2.3-41 (Continued)

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS			
		Population Fluctuation	Age at loss of Parental Care (i.e. fledgling)	Reproductive Season(s)	Life Span
Common Snipe	Usually on wet grassy areas such as low pastures & wet meadow types; also on mud flats & shores adjacent to open water. (3)	4 (19)	Inc = 18-20 days (19)	Egg dates: May 8 - July 24 (19)	
Mourning Dove	Common in suburbs & farmland. (1)	2 (6)	2 (14)	Inc = 15 days (14)	Up to 9 yrs. (20)
Red-headed Woodpecker	Open groves of large trees or in groups of scattered trees in open fields. (22)	4-7, mostly 5 (22)	1-2 (22)	Inc = 14 days (22)	Mid-April Nestling Period July (3) 2 wks. (14)
Cliff Swallow	Open country, usually in the vicinity of unpainted barns. (3) Occurs about bridges and dams on major watercourses and impoundments. (16)	4-5 (16) 3-6, usually 4-5 (23) (23)	2 (23)	Inc = 12-14 days (23)	Early May to late June (3) (3)
Bewick's Wren	Various edge habitats in the vicinity of farm houses or in towns. (3) Open wood lots, upland thickets and hills, fence rows near houses and orchards. (4)	5-7 (24) 4-5 (23)	2 (24)	Inc = 10-14 days occas- ionally 3 (24) (24)	Late April Nestling Period July (3) 14 days; may feed young for 2 weeks after leaving nest. (24)

TABLE 2.3-41 (Continued)

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS					
		Population Fluctuation	Reproductive Season(s)	Life Span	Brooding (Br) Incubation (Inc) Gestation (G)	Clutches/Litters per year	Clutch/Litter size
Grasshopper Sparrow	Various types of hayfields, overgrown pastures and weedy fallow fields occasionally broomsedge fields. (3)	4-5 (25)	2 (25)	Inc = 12 days (25)	1st nestling - Late May 2nd nestling - Late June or early July (25)		
Marsh Hawk	Breeding-tidal marsh, marsh-meadow & upland sedge meadows. Transient & wintering - open agricultural & tidal marshes. (1)	5 most common (4)	Inc = 31 days (4)	Inc = 21 days (18)	Early Apr. to mid-July (3)	About one month (18)	Age at 1st flight to Mid-July (3) 30-35 days (4)
Common Gallinule	Occurs in vicinity of ponds in brackish marsh types, including narrow-leaved cartail needle rush; also occurs on inland marshes. (3)	6-17, mostly, 10-12					
Upland Sandpiper	Breeding-Agricultural areas with extensive hay fields and pastures, usually on land with a slightly concave contour. Transient-various types of open fields and meadows, less frequently, in marsh and shore habitats with short or sparse vegetation. (3)	4, occasionally 3 or	Inc = 17 days (26)		Early May to late June (3)		

TABLE 2.3-41 (Continued)

References

- (1) Robbins et al., 1966 (Ref. 2.0-40)
- (2) Bent, 1923 (Ref. 2.0-41)
- (3) Stewart and Robbins, 1958 (Ref. 2.0-43)
- (4) Bent, 1937 (Ref. 2.0-42)
- (5) Fisher, 1893 (Ref. 2.0-44)
- (6) Warren, 1888 (Ref. 2.0-45)
- (7) Porath and Vohs, Jr., 1972 (Ref. 2.0-46)
- (8) Sharp, 1963 (Ref. 2.0-47)
- (9) Johnston, 1971 (Ref. 2.0-48)
- (10) Marshall, 1954 (Ref. 2.0-49)
- (11) Andrle, 1971 (Ref. 2.0-50)
- (12) Gates, 1966 (Ref. 2.0-51)
- (13) Allen, 1956 (Ref. 2.0-52)
- (14) Bent, 1932 (Ref. 2.0-42)
- (15) Pearson, 1917 (Ref. 2.0-53)
- (16) Barbour et al., 1973 (Ref. 2.0-54)
- (17) Hewitt, 1967 (Ref. 2.0-55)
- (18) Bent, 1926 (Ref. 2.0-56)
- (19) Bent, 1927 (Ref. 2.0-57)
- (20) Welty, 1962 (Ref. 2.0-58)
- (21) Stoner, 1932 (Ref. 2.0-59)
- (22) Bent, 1939 (Ref. 2.0-60)
- (23) Bent, 1942 (Ref. 2.0-61)
- (24) Bent, 1948 (Ref. 2.0-62)
- (25) Bent, 1968 (Ref. 2.0-63)
- (26) Bent, 1929 (Ref. 2.0-64)

TABLE 2.3-42: SOME IMPORTANT SPECIES OF MAMMALS LIKELY TO OCCUR AT RAAP - THEIR LIFE HISTORIES, AND HABITAT REQUIREMENTS

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS					
		Age at Maturity	Clutch/Litter size	Clutches/Litters per year	Brooding (Br) Incubation (Inc) Gestation (G)	Reproductive Season(s)	Population Fluctuation
Indiana Bat <i>Myotis sodalis</i>	Caves in winter man-made structures and possibly hollow trees in summer. (1)	1 (2)	1 (2)	1 (2)	(G) = 50-60 days (3)	12 yr. (3)	Large winter colonies, scurries, dispersion takes place late April to early May. (2)
Western Big-eared Bat	Caves, cliffs, rock edges in well drained oak-hickory forests; caves in beech-maple-hemlock forests. (2)	Females may breed at 4 months, males, 1 year (2)	1 (2)	1 (2)	(G) = 56 to 100 days (2)	19 yr. (2)	Breeds in fall. Born in late June
Black Bear	Forests and swamps. (1) Males range 15 mi. or more, female less. Unusually solitary except female with cubs. (1)	First mate 3 1/2 yrs. (1)	Normally 2, occasionally 1 or 3 yrs. (1)	1 litter every other year (1)	(G) = 7-7 1/2 (1)	30 yr. (1)	Young born in Jan. or Feb. (1) Weaned at 8 mo. but may stay with mother for 1st yr. (1)

TABLE 2.3-42 (Continued)

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS							
		Age at Maturity	Clutch/Litter size	Clutches/Litters per year	Brooding (Br) Incubation (Inc) Gestation (G)	Reproductive Season(s)	Life Span	Population Fluctuation	
Red Fox	Rolling farmland mixed with wooded acres, marshes and streams. (5) Home range 1000 acres. (6)	Breeds at 1 yr. (7)	4-9 (1)	1 (1)	(G) = 51 days (1) (4)	12 yrs. in captivity (7)	Mates in March or April (1)	5 months (5)	
Gray Fox	Brushy country, woodlands, swamps and hammocks. (7) Dens in hollow logs beneath boulders, or ground burrows. (1)	May not breed until 2 yrs. (7)	3-7 (1)	1 (1)	(G) = 51+days (1)	10 yrs. in captivity (1) (7)	Mates in March or April-May (1)	Weaned 8-10 wks (7)	
Bobcat	Swamps and forests. Dens in rock crevices, hollow logs, beneath downfalls. Range usually within 2 mi. radius. (1)	Breeds at 1 yr. (7)	2-4 (1)	1 (1)	(G) = 50-60 days (1)	15-25 yrs. in captivity (1)	Mates in spring normally. Born any month, mostly spring (1)	Leaves mother 6-12 mo. (1) Weaned at 2 mo. (7)	
Eastern Gray Squirrel	Hardwood forests with nut trees, river bottoms. Home range 2-7 acres. (1)	3-5 (1)	2 (1)	(G) = 44 days (1)	Up to 15 yrs. in captivity (1)	Jan-Feb. 5 June in North (1)	Weaned at 2 mo. (1)	2-20 per acre (1)	

TABLE 2.3-42 (Continued)

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS					
		Age at Maturity	Clutch/Litter size	Clutches/Litters per year	Brooding (Br) Incubation (Inc) Gestation (G)	Reproductive Season(s)	Population Fluctuation
Eastern Fox Squirrel	Open hardwood woodlots with clearings interspersed. Home range 10-40 acres. (1)	Females breed at 1 yr. (1)	2-5 females Older females 2 litters (1)	Yearlings (G) = 1 litter, 44 days (1)	10 yrs. Born Jan-July. Born Feb., April & Aug.-Sept. (1)	Weaned 2-3 mo. (1)	
Snowshoe Hare	Swamps, forests, thickets. Home range about 10 acres. (1)	Breeds at 1 yr (7)	1-7 usually 2-4 (1)	2-3 litters 36-37 days (1)	3 yrs. In wild, 8 yrs. In captivity (1)	Born April-Aug (1)	Weaned 1 mo. (7)
Eastern Cottontail	Heavy brush, strips of forest with open areas nearby, edge of swamps, weed patches. (1)	9-10 months (7)	4-7 (1) 4-5 (7)	(G) = 26-30 days (G) = 28 days	Born mostly Mar-May, also to Sept (1)	15 days to several acre (1)	Fluctuate tremendously, highs every 11 years (1)
New England Cottontail	Brushy areas, open forests, rough int. terrain. (1)						

TABLE 2.3-42 (Continued)

SPECIES	HABITAT REQUIREMENTS	POPULATION DYNAMICS					
		Population Fluctuation	Age at loss of Parental Care (i.e. fledgling)	Reproductive Season(s)	Life Span	Brooding (Br)	Incubation (Inc)
							Gestation (G)
Whitetailed Deer	Open meadows, swamps, valleys. (5) Needs 1 sq. mi. range. (4) Forests, swamps and open brush areas. (1)	filled yrs. usually (4) 2, 1-3 m-2½ yr. (1)	usually (5) 7 months (1)	1 (1)	12 yrs. (14) 7 months (5) 16½ yrs. (1)	Oct.-Dec. Fall (4) at 4 months (5)	Weaned (1)
Virginia Deer							

TABLE 2.3-42 (Continued)

References

- (1) Burt and Grossenleider, 1964
- (2) Barbour and Davis, 1969
- (3) Schwartz and Schwartz, 1959
- (4) Cahalane, 1947
- (5) Hamilton, 1943
- (6) Storm, 1965
- (7) Palmer, 1954

TABLE 2.3-43: LIFE HISTORY CHARACTERISTICS OF GAME FISH COLLECTED FROM THE NEW RIVER AT RRAP

SPECIES	FEEDING HABITS	SPAWNING HABITAT	SPAWNING SEASON
Rock Bass	Carnivorous-invertebrates and fish(1)	Nest in shallow depressions excavated by male(1) gravel bars(2)	Spring (1)
Red-bellied Sunfish	Carnivorous-crustaceans insects and fish(2)	Hard sand and gravel preferred but other types used for nests(2)	Spring (1)
Green Sunfish	Carnivorous (1)	Nest in shallow depressions (1)	Spring (1)
Pumpkinseed	Carnivorous-mollusks insects and occasionally fish(2)	Prefers sandy bottoms but will use dirt and clay - shallow water(2)	Summer (2)
Bluegill	Carnivorous-largely insects some plants(2)	Hard sand and gravel preferred but other types used for nests(2)	Summer (2)
Smallmouth Bass	Carnivorous-invertebrates and fish including crayfish and amphibians(2)	Male fans out nest in gravel bottom, pool but some current, less than 5 feet deep (2)	Spring when water reaches 65° F (2)
Spotted Bass	Carnivorous-invertebrates and fish including crayfish and amphibians(2)	Male fans out nest in gravel bottom, pool but some current, less than 5 feet deep (2)	

(1) Hubbs C.L. and K.F. Lagler, 1947. Fishes of the Great Lake Region. The Univ. of Michigan Press, Ann Arbor

(2) Shorom, J.J. (ed), 1955. Freshwater fishing and fishlife in Virginia, Commonwealth of Virginia, Comm. of Game and Inland Fisheries, Richmond, Va.

TABLE 2.3-44: FISH SPECIES COLLECTED AT RAAP (1) WITH HABITAT AND TOLERANCE CHARACTERISTICS

SPECIES	Common Name	Scientific Name	TOLERANCES		
			HABITAT		
			Clear Water	x	x
			Silty Water	(2)	2.5-29.3°C (4) intolerant of low O <sub>2</sub> (5)
			Small Streams	x	
			Lakes	x	
			Sandy Streams	x	
			Vegetation	x	
			Riffles	x	
			Pools	x	
			Rivers	x	
			Rocky Steams	x	
Common Sucker*		<u>Catostomus commersoni</u>			
Hog Sucker		<u>Hypentelium nigricans</u>	x (2)	x	x
Stoneroller		<u>Campostoma anomalum</u>	x (2)	x	x
Mountain redbelly dace		<u>Phoxinus oreas</u>			
Blacknose dace		<u>Rhinichthys atratulus</u>		x (2)	29.3°C (4)
Bluntnose minnow		<u>Pimephales notatus</u>		x (2)	4.2-33.3°C (4)
Carp		<u>Cyprinus carpio</u>	x (5)	x	35.5°C (6)
Big mouth chub		<u>Nocomis platyrhynchus</u>			
Blue head chub		<u>Nocomis leptocephalus</u>			
Rosefin Shiner		<u>Notropis ardens</u>		x (2)	x
White Shiner		<u>Notropis alboeolus</u>			

TABLE 2.3-44 (Continued)

SPECIES	Common Name	Scientific Name	TOLERANCES	
			HABITAT	WATER
Common Shiner		<u>Notropis cornutus</u>	x (2)	x
Spottail Shiner		<u>Notropis hudsonius</u>	x (2)	
Whitetail Shiner		<u>Notropis galacturus</u>	x (3)	
Spotfin Shiner		<u>Notropis spilopterus</u>	x (2)	x
Swallowtail Shiner		<u>Notropis procne</u>	x (2)	x
Rosyface Shiner		<u>Notropis robellus</u>	x (2)	x
Telescope Shiner		<u>Notropis telescopus</u>		
Mimic Shiner		<u>Notropis volucellus</u>	x (2)	
Margined Madtom		<u>Noturus insignis</u>		
Greenside darter		<u>Etheostoma blennioides</u>	x (2)	x

TABLE 2.3-44 (Continued)

SPECIES	Common Name	Scientific Name	HABITAT		TOLERANCES
			Clear Water	Silty Water	
	Fantail darter	<u>Etheostoma flabellare</u>	x (2)	x (2)	
	Piedmont darter	<u>Percina crassa</u>			
	Yellow Perch*	<u>Perca flavescens</u>	x (2)	x (2)	3.7 ~ 29.7°C (4)
	Rock bass*	<u>Ambloplites rupestris</u>	x (2)	x (2)	
	Redbelly sunfish*	<u>Lepomis auritus</u>			
	Green sunfish*	<u>Lepomis cyanellus</u>	x (2)	x (2)	
	Pumkinseed*	<u>Lepomis gibbosus</u>	x (2)	x (2)	
	Bluegill*	<u>Lepomis macrochirus</u>	x (2)	x (2)	2.5 ~ 33.8°C (4)
	Smallmouth bass*	<u>Micropterus dolomieu</u>	x (2)	x (2)	x Require silt free waters (5)
	Spotted bass*	<u>Micropterus punctulatus</u>			

TABLE 2.3-44 (Continued)

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## 2.4 ENVIRONMENTAL IMPACTS

2.4.1 Socioeconomics. The socioeconomic impact of construction of a nuclear reactor at the proposed site is largely dependent upon the size of the construction work force and the duration of construction activities. Work force size greatly influences both the ability of the nearby areas to supply labor and the ability of local areas to accomodate construction and management personnel who may have to relocate to the area. An influx of personnel associated with construction and operation of the plant will place demands upon local housing, schools, and public services.

The area which may sustain impacts from the construction activities is that area within a 60 to 75 mile radius, or one to one and one-half hours commuting distance. Within this radius there are a number of small to moderate-sized towns (Pulaski, Radford, Christiansburg, and Blacksburg) and a Standard Metropolitan Statistical Area (Roanoke). These towns should be able to supply a majority of the labor foce and thus minimize the potential impacts of an influx of new labor.

An impact related to the irreversible commitments of resources is the allocation of land for construction activities and for the plant site proper. Since the proposed plant is going to be constructed within the confines of Radford Army Ammunition Plant, and hat this area has already been zoned industrial, there will be no impacts on consumptive land use.

Since the proposed plant construction is a federal activity and will be located on a federal military facility, it will not have any impact on the property tax base. Because of this, the only other major impacting medium will be employment. Presented in chapter three is an idealized construction schedule of three and one-half years during which time a

maximum of 666 persons will be employed at any given time. The peak average employment is estimated at 650 persons for fifteen (15) months. The largest contribution of personnel to the work force will come from the craft workers.

The ability of most workers to commute from within a seventy-five (75) mile radius will virtually eliminate the need for local housing, thus the impact on community services (schools, police, hospitals, etc.) will be minimal since most of the needs of the workers will occur at their own homes, not at the construction site. Certain parts of the labor force - construction management personnel, vendor's representatives, and the owner - may permanently reside in areas where commuting is not practical. In these cases, personnel may reside in transient housing (hotels, motels, etc.) during the week and return home on weekends. This could put a slight strain on local motels and boarding houses.

Within commuting range (50-70 miles) of the proposed site there are over 16,000 persons employed in the construction industry.\* It is assumed for the purpose of this study that from this labor pool, the local area can supply all the labor with the exception of those highly specialized skills unique to the nuclear industry. Assuming the Corps of Engineers does not construct the plant, it is estimated that a maximum of one hundred (100) persons will not be able to commute to the job site. Of this number, a maximum of fifty (50) persons will bring their families.

During the operating life of the plant, which is estimated to be between thirty (30) and forty (40) years, approximately seventy five (75) persons will be employed in operating, maintaining, and providing security at the plant.

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\*Source: U.S. Census of Population, 1970.

A result of the primary employment caused by construction activities, a certain amount of secondary employment will be generated as supporting services. The Base Employment Multiplier is a reasonable representation of how total employment in a region is related to base employment. This study assumes a multiplier of 2.5; that is, for every primary job generated by construction activities, there are 1.5 secondary jobs induced.

The induced employment and population can be calculated as follows:

- (a) Of the total work force, 100 persons reside in the area with their families for a total ( $\times 3.2$ ) of 320 residents.
- (b) For the 100 persons moving into the area ( $\times 1.5$ ) 150 new (secondary) jobs are created.
- (c) For the 150 new jobs, the population is increased by a factor of 3.2 for an induced population of 480 persons.
- (d) The total induced population (A) + (C) is 800 persons.
- (e) The total induced employment (B) + (D) is 250 persons.

The increase in secondary employment and the increase in population will not react immediately to the construction activities; rather there will be a lag time between the two..

For the sixty (60) positions created by the operation of the plant, ninety new (secondary) jobs will be created, for a total of one hundred fifty (150) new jobs. Compared to the construction jobs, these positions can be considered permanent. Using the 3.2 multiplier of persons per household, the population of the surrounding area will be increased by almost five hundred (500) persons.

The primary impact of the population increase will be on community services. From the population projections and growth rates presented in

subsection 2.1.3.5, the population of Montgomery County increased by 43% between 1960 and 1970, and during the same period the population of Christiansburg increased by 115%. With such rapid growth, it is doubtful that the population generated by the proposed facility will have a major impact. It can be assumed that all community service functions are now operating at full mobilization due to the increase of the sixties. Hence the impact of induced population can then be considered a negative impact. The question is then how large will this impact be or will it just aggravate an already serious problem.

It should also be realized that there will be beneficial impacts associated with the proposed project. For instance, it generates primary and secondary employment; and homes purchased by new residents will generate increased revenues in the form of local real estate, property, and income taxes.

At this time it is not possible to determine the overall net socio-economic impacts resulting from the construction and operation of the proposed facility. However, it would appear that because of relatively short schedules and small peak manpower requirements (compared to large commercial plants), the net impacts will be negligible.

2.4.2 Land Use and Zoning. The issues of land use and zoning have been partially addressed in section 2.4.1, Socioeconomics, and in the section dealing with prime site identification.

A preliminary plant layout for the proposed facility requires approximately eleven (11) acres for the plant site proper. Another twenty (20) acres will be required for construction support facilities along with a storage and laydown area. These twenty acres will, in part, be rejuvenated once construction is complete.

Additional impacts concern the Exclusion Area and Low Population Zone. Within the exclusion area radius, tentatively set at 0.4 miles, the applicant will have the authority to control activities. This will no doubt preclude the use of this area as a potential residential site. However, the area is already partially zoned for industrial use, minimizing any negative impacts of consumptive land use. By prior arrangement and agreement, it is possible that the area may be used for other industrial applications which are not labor intensive.

The Low Population Zone, which includes a large portion of the ammunition plant, does not preclude the areas outside the ammunition plant from alternative land uses. However, the resident and transient population in the LPZ should be considered in order to provide a reasonable assurance that the population can be evacuated in the event of an emergency. Should the population in the LPZ increase drastically, the Department of Defense will have to revise evacuation plans, or in extreme cases, make changes to the plant in order to provide increased protection.

2.4.3 Transportation. Construction of the proposed facility should not create any additional impacts above and beyond those of the movement of work force and material. It is likely that traffic along State Routes 114 and 659 will increase, but not by a very significant amount. The plan access road will join Route 114 and possibly cause some minor congestion during peak traffic hours. A traffic signal or patrolman may be necessary to control the flow of traffic.

Operation of the plant's cooling towers could cause fogging and icing along state Route 659 in the vicinity of the site, which in turn could create poor visibility for motorists. Heavy fogging occurs throughout the

area of southwestern Virginia with a frequency of 25 to 40 times per year. In the winter and autumn seasons, light fog is practically a daily occurrence. It can be assumed that periods of heavy fog will increase in the vicinity of the site, but until detailed calculations are performed utilizing site-specific data, the nature and amount of increased fog will be unknown.

2.4.4 Ecology. The primary impacts on the terrestrial biological system can be divided into the construction and operational phases of the proposed facilities. The largest impact during both phases will be associated with the physical removal and complete destruction of a wildlife habitat.

The major effects of power plant construction are: 1) removal of habitat; 2) increases in human activity, 3) increased ambient noise, 4) increased atmospheric dust, and 5) increased erosion.

The greatest impacts will result from the total habitat destruction. Table 2.4-1 presents land acreages to be cleared for each facility, present biological habitats, and future restoration plans. A total of eleven (11) acres, most of which is presently wooded, will be directly disturbed during construction. Thirty-five (35) acres are considered unrestorable due to the construction of permanent structures and roads. Twenty-one (21) acres will be maintained in an early successional stage of forbs and grasses while an additional twenty-one (21) acres will be left to revert to forest. The latter process will require at least one hundred (100) years. It is assumed that organisms inhabiting the cleared area will be eliminated either directly, through competition, lack of food, or by reproductive failure. Woodland species will be heavily affected. Mammal dispersal will

be inhibited by fences surrounding the ammunition plant and around the construction site. Caves which could serve as habitats for the Virginia big-eared bat should be noted and examination should be made to determine their presence or use before construction begins.

Because of the initial construction operation of clearing the woodland, along with the steep slopes present at the site, erosional problems are likely to occur even though extreme care will be taken. Erosion at the site area can deplete the soil of its nutrients while deposition of eroded materials offsite may have a smothering affect on healthy vegetation.

Increases in human activity and increased noise levels will disturb organisms near the construction site and may cause their migration to quieter areas. However, because of activities at RAAP and traffic on Route 659, the present animals are already subject to considerable human disturbance and may be partially accustomed to it. Dust generated during excavation and construction can coat plant leaves and reduce photosynthesis. Care will be taken to dampen dust-prone areas during dry periods.

Operational effects on the terrestrial biological system will arise mainly from increased human presence, and plant noise. Noise and human presence will be at greatly reduced levels as compared to those levels experienced during excavation and construction.

The impacts on the aquatic environment are the results of changes and activities both within the water bodies and associated land areas of their watersheds.

Construction activities within the New River will be limited to the construction of the intake and discharge structures in association with cooling towers along the New River, and the construction of a steam line

across the river to powerhouse number two. Dredging, ripping and/or blasting if required for construction, may temporarily increase turbidity. The nature and extent of the suspended sediments will depend on the type of substrate which is disturbed. Turbid conditions can reduce productivity of aquatic plants by reducing light penetration, clog the gills of benthic invertebrates, and destroy nest sites and eggs of fish. However, due to the temporary nature of construction activities many tasks could be performed during winter when productivity is low and spawning activity has stopped. A more problematical increase in turbidity and siltation is likely to occur from clearing and earthmoving activities. Preventing measures such as rapid seeding, mulching, and construction of retention basins help reduce these impacts.

An associated problem occurs when forested areas are cleared. Ions, especially nitrates, which were formerly bound in the soil are released from the cleared region into local streams. Stroubles Creek is particularly vulnerable to nutrient and sediment additions because of its location immediately adjacent to the site. Road construction (Route 659) along this creek has already affected the diatom and benthic communities.

Operational impacts on the aquatic environment are primarily associated with the intake of water from the New River and the proposed discharge of blowdown into Stroubles Creek. Additional effects are related to the possible release of radioactive materials and chlorides into waters receiving cooling water discharges and blowdown.

There are two separate problems related to water intake: impingement and entrainment. Impingement refers to the process in which organisms (primarily fish) are pulled and held against intake screens due to the

force of intake pumpage. Those fish most susceptible are those too small to swim against the intake water velocity, and compressed fish which present a broader surface area to the current. Placement of the intake in an area of rapid current and off of the river bottom should minimize the presence of fish susceptible to impingement. Entrainment refers to the inclusion of small organisms able to pass through the screens into the intake water and through the cooling system. Because cooling towers will be used at the proposed facility, the impact of entrainment and impingement should be negligible due to the ion flows required for cooling.

Blowdown from the cooling towers will probably be discharged into Stroubles Creek. The water will contain a concentration of dissolved material at five times the concentrations presently in the waters of the New River. The concentration of total solids will be in the range of 300-500 ppm with chloride and sulphate concentrations of 15-20 and 35-65 ppm, respectively. Fresh water is commonly defined as waters having "dissolved salt" concentrations of less than 500 ppm. Most freshwater fish and invertebrates are tolerant of higher salt concentrations. Temperature of the discharge will be approximately 80°F under wet bulb conditions of 72°F. This could appreciably raise the temperature of Stroubles Creek under adverse meteorological conditions of high temperatures and high humidities. The creek presently receives effluent of 82°F near the TNT area.

EPA (Committee on Water Quality Criteria, 1972) recommends that total residual chlorine should not exceed 0.05 ppm for a period up to 30 minutes in any 24-hour period in order to protect aquatic life. Higher levels are being proposed here, with free available chlorine being discharged for a maximum of 2 hours per day at average concentrations of 0.2 ppm and maximum concentrations of 0.5 ppm. It is expected that the increased

concentration of salts, the thermal increases, and the levels of chlorine proposed, coupled with the low discharge rates of Stroubles Creek will produce additional stress and will further degrade the creek's biological communities. The creek is presently under great stress and does not support valuable biological communities.

TABLE 2.4-1  
HABITATS TO BE IMPACTED IN CONSTRUCTION OF THE PROPOSED PLANT WITH RESTORATION PLANS

Facility	Area which will be cleared	Present Habitat	Restoration
Plant site proper	11 acres	Mixed hardwood forest	Little potential - mostly covered with buildings structures and roads
Lay down areas			
A. Adjacent to Plant			
B. 3200' south of plant	A. 9 acres B. 21 acres	Mixed hardwood forest	A. Portion remain as service area B. Seeded in grasses and allowed to undergo succession
Make up waste and blowdown pipes	80' wide 7.5 acres	Mixed hardwood forest recently lumbered forest herbaceous vegetation	Maintained in forbs and grasses
Steam distribution Pipelines	40' wide 20 acres	Mixed hardwood forest hardwood forest herbaceous vegetation	Little restoration because of road and vegetation maintenance as grasses
Transmission Line Corridor	100' wide 4 acres	Mixed hardwood forest	Maintenance as forbs and grasses - maybe shrubs
Access road	60' wide 5.5 acres	Mixed hardwood forest	Little restoration

## 2.5 COMPLIANCE WITH FEDERAL SITING GUIDELINES

2.5.1 Demography. With respect to the siting guidelines presented in subsection 2.2.3.7, the site complies with all the Nuclear Power Plant siting guidelines presently in effect. However, there are two areas which may cause licensing difficulties.

The first is the traverse of new State Route 659 through the Exclusion Area. Although the guidelines do not specifically prohibit such uses of the exclusion area, these uses are discouraged. It will remain the responsibility of the applicant to show that all activities occurring within the Exclusion Area can be controlled in the event of a public safety accident. Furthermore, a more detailed evaluation of potential transportation-related accidents will be required by the Nuclear Regulatory Commission.

The Low Population Zone's present population density does not preclude the use of the site for a nuclear power reactor. However, because of rapid population growth in Montgomery County, population in the LPZ in the future may create a problem. The applicant, unless he owns the property included in the LPZ, has to negotiate with local authorities concerning activities in this area. If population levels increase to a point where existing evacuation plans are no longer suitable, the NRC may require new plans demonstrating the applicant's ability to evacuate the area. However, in the extreme case where evacuation is not a viable means of controlling accident consequences, the applicant may be required to install additional special protective features at the plant. One means of preventing residential development is by the purchase of properties in the LPZ in addition to seeking changes in the present zoning.

2.5.2 Meteorology. The lack of site-specific data and subsequent analyses makes it difficult to ascertain the degree of compliance of meteorological parameters with federal siting guidelines. However, based upon the available data presented in subsection 2.3.3, there does not appear to be any insurmountable problems with respect to licensing.

2.5.3 Hydrology. In general, most of the hydrological effects of the proposed plant and site combination on the New River appear to be minimum and in compliance with the siting criteria presented in subsection 2.2.3.5. It is possible that the blowdown discharged to Stroubles Creek may exceed EPA standards. The effect of domino-like dam failures upstream of the plant site has not been identified as required by the NRC. However, the elevation of the proposed plant at site #3 above the New River (approximately 180 feet) would almost preclude any flooding at the plant. Some analysis documenting this evaluation should be provided.

2.5.4 Geology and Seismology. Based on the interpretation of the site area's geological characteristics and the seismic history of the area, there appears to be no deleterious characteristics that would preclude licensing. Faults occur near the site but they are believed not capable by NRC definitions. However, this should be substantiated. The seismic design value for the Safe Shutdown Earthquake (.25-.30g) is believed to be adequate but also should be verified.

2.5.5 Aquatic and Terrestrial Ecology. Within this report, aquatic and terrestrial ecology have been discussed rather thoroughly. It is known that much more information exists concerning the ecology of the New River, RAAP, and areas adjacent to the site. However, these data were not

supplied to the consultant. Knowing that these data are available but have not been reviewed, it is not possible to reasonably state the degree of compliance with Federal Guidelines. The effects of chemical and thermal discharges on the aquatic environment, especially in Stroubles Creek, will need to be examined before any definitive impact statements can be made.

**2.6 RECOMMENDATIONS FOR ALTERNATIVE COURSES OF ACTION AND ADDITIONAL WORK**

2.6.1 Assessment of Data Availability and Analyses. Throughout the greater portion of this report, data availability, and particularly the availability of site-specific data, has been cited as a major drawback of the study. However, this is not to say that many of the conclusions drawn from the available information are not valid. Rather, within the intent and purpose of the study, the assessment of the suitability of Radford Army Ammunition Plant for locating a 313 MW<sub>t</sub> nuclear plant, the information provided by the Department of Defense and additional data collected by the consultant provides an adequate data base for such an assessment. Much of the analyses performed for the study are primarily preliminary in nature and based on regional data because there is very little site specific data available.

2.6.2 Comparison of the Difference in Environmental Impacts: Coal vs. Nuclear. An evaluation of environmental impacts connotes a comparison of impacts between alternative land uses. With this in mind, it is suggested that the proposed nuclear plant be compared with a coal fired station of the same capacity.

The construction of small nuclear reactors by Federal agencies (with particular emphasis on the Department of Defense) to meet long-term energy demands and diminish the nation's reliance on foreign fuel sources should also be viewed as a siting consideration that may offset possible economic penalties and environmental impacts.

2.6.3 Further Definition of the Prime Site. In the preceeding subsections, candidate site three (.) has been identified as the prime site for locating the Consolidated Nuclear Steam Generator at RAAP. It must be noted that this site is not without certain deleterious characteristics that may adversely impact the costs of construction and initial access; but the site is, nevertheless, the most suitable of the three specific site areas.

Also, it is believed that economic advantages (in the areas of excavation and construction) may be gained by slightly relocating the proposed plant within the general area of site three. Such a relocation may minimize the effects of potentially hazardous land uses (State Road 659 and the Norfolk and Western Railroad) on plant design and also alleviate potential licensing problems due to these land uses.

## 2.7 Applicability of the Proposed Facility to Other Military Sites

### 2.7.1 Tentative Envelope of Behavior for Other Hypothetical Sites.

A concept that has yet to be examined is the partial standardization of the design of the proposed plant and the potential application of these designs to other sites. The Nuclear Steam Supply System and the balance of plant, as designed for site conditions at RAAP, should be applicable over a wide range of sites throughout the United States. The mix of steam and electricity along with back-up energy requirements will probably be the initial consideration for applicability to other sites. The following is a summary of probable plant requirements.\*

2.7.1.1 Demography. The exclusion area and low population zone may vary greatly in their respective sizes depending on reactor and balance of plant design along with on-site meteorological conditions. The exclusion area and low population zone have been tentatively set at radii of 0.4 and 3.0 miles, respectively for this study. Because the reactor is of small capacity it is likely that the exclusion area and LPZ can be much smaller also. This will permit other activities (manufacturing) to be carried on in the site vicinity without actually being within the exclusion area radius.

2.7.1.2 Meteorology. The proposed site is located in Design Basis Tornado Region I which includes that part of the contiguous forty-eight states east of the Rocky Mountains. A plant that can withstand the Region I Design basis tornado can also withstand the Design basis tornadoes of Regions II and III, west of the Rocky Mountains.

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\*Based on Wash 1355 and Design at RAAP

The 100-year return period wind (fastest mile wind) is 90 miles per hour. This is generally referred to as the Operating Basis Wind Speed at which the plant can operate without any loss of function. The 90 mph value is fairly high and is suitable for nearly all areas of the United States exclusive of coastal areas. Coastal areas may experience a fastest mile wind speed of up to 130 mph. For the purposes of this study it is assumed that the plant will be designed to withstand a 130 mph wind.

The overpressure resulting from a postulated explosion on a nearly transportation route at RAAP has been calculated to be approximately 10 psi above ambient conditions. This is a conservatively high value that probably would not be applicable to other sites unless they were also adjacent to hazardous manufacturing facilities.

2.7.1.3 Hydrology. Total plant water requirements at RAAP are estimated to be 2200 gpm (5 cfs) for a cooling tower system. Of this amount 750 GPM (1.7 cfs) are used for make-up, 1250 GPM (2.8 cfs) for process steam, and 200 GPM (0.45 cfs) for service water make-up. The maximum water requirement for a plant using once through cooling and producing all process steam will be approximately 17,000 GPM (38 cfs); once through cooling with 100% electric production approximately 15,300 GPM (34 cfs). A plant producing all electricity but with cooling towers would be using approximately 950 GPM (2.2 cfs).

With respect to large commercial nuclear plants these water requirements are quite small. Rivers, lakes, and reservoirs with an available water resource (10% of the 7-day; 10-year recurrence low flow) of 22 to 380 cfs will be suitable sites for a 313 MW plant so long as their diffusion characteristics are suitable for adequate dissipation of waste heat.

2.7.1.4 Legal Restrictions. As a final consideration in the siting envelope, the impact of new state legislation restricting the proliferation of nuclear power should be assessed to determine how it may affect nuclear power plant siting by a federal agency. Many states have passed or initiated legislation setting environmental standards and some states have set up siting boards and councils to oversee and review candidate sites for thermal power plants. However, the defeat of an initiative recently in California (June 8, 1976) could be interpreted as a growing awareness among the people of that state that nuclear power is necessary in order to maintain continued economic growth and a high standard of living.

2.7.2 Possible Releases from NRC Criteria. Since the proposed reactor's design is somewhat unique and of much smaller rated capacity than commercial units, it may be possible for the applicant to obtain waivers on some of the NRC's present criteria. To do this, it would be necessary to perform detailed studies demonstrating that the design warrants these waivers.

2.7.3 Summary. Based on existing federal siting guidelines and criteria the Radford Army Ammunition Plant has been evaluated as a potential location for a small ( $313 \text{ MW}_t$ ) nuclear reactor that will provide both process steam and electricity to the manufacturing facilities. Possible prime site locations were evaluated using data supplied by the Department of Defense. Three candidate sites located within the boundaries of RAAP were identified, evaluated and rated as to which was the most suitable location. Site three (3) (Figure 2-3) was suggested to the Department of Defense as being the most suitable of the three areas, but nevertheless, it has certain deleterious characteristics (topography; layout area available) that could limit its use. The site was then evaluated in detail and

found to be viable based on the supporting data. The evaluation suggests that some subjects should be examined in more detail using site-specific data, specifically the exclusion area radius, the LPZ, transportation hazards, and local geology and foundations. Recommendations for additional work include:

- (1) Further definition of an adequate Exclusion Area radius for the PE-CNSG. Radii less than the tentative values presented in this report should broaden the reactor's applicability to other sites.
- (2) The potential for missile generation and explosions from RAAP, from the eastern branch of the Norfolk and Western Railroad, and from State Route 659 should be evaluated in more detail. Although the Norfolk and Western Railroad has not been able to supply information at this time concerning the types, amounts, and frequency of transportation of hazardous materials carried through the site area, further discussions should be initiated with the railroad to determine the nature of these shipments.
- (3) Should the project go forward, a meteorological tower should be constructed at the site. This will provide on-site data that can be used to determine the operating characteristics of the cooling towers, to project the amounts of heavy fog (if any) caused at the site from the towers, and to be used as input for the determination of the Exclusion Area Radius and Low Population Zone. The construction and operation of such a tower and recording of meteorological data for site-specific design purposes could shorten the design and licensing schedule.

- (4) The effects of dam failure both upstream and downstream of the site should be evaluated. Also, the Possible Maximum Flood requires further analysis as does the general hydrology of the New River and Stroubles Creek at RAAP.
- (5) The potential for ground water contamination of the Price and Mecrady Formations at the site should be investigated. Local ground water users should be identified in order to determine the impacts of potential contamination.
- (6) More extensive geological and seismic investigations in the site and near vicinity are indicated. Specifically, these studies would entail the performance of geologic and foundation borings, local geologic mapping, and further analysis of the Safe Shutdown and Operating Basis Earthquakes. Soil and rock samples recovered from the boring investigation should undergo laboratory testing to determine what the allowable foundation loads may be and to predict settlements.
- (7) It is also recommended that discussions with the Nuclear Regulatory Commission be initiated in order to define the possibility of obtaining waivers from certain regulations and guidelines based on the unique design of the PE-CNSG. For example, the Low Population Zone and Exclusion Area Radii may be lessened based on what is believed to be a more conservative design.

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